Numerical modeling of pollutants dispersion of Khatun-Abad smelting chimney with the satellite images and ERA database

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Abstract

Air pollution caused by industrial activities, particularly copper smelting factories, is one of the significant and complex challenges in the field of the environment. The chemical pollutants and suspended particulate matter resulting from the copper smelting process have serious impacts on air quality and human health. In this context, modeling air pollution from copper smelting factories has emerged as a powerful tool for analyzing and predicting the dispersion of pollutants and assessing their effects on the environment and human health This research aims to provide optimization and control methods for air pollution arising from copper smelting factories and to examine the impact of the Khatoonabad copper smelting factory on the climatic parameters of the Khatoonabad plain. In this study, the dispersion of pollutants emitted from the chimney of the Khatoonabad smelting factory was modeled using climatic data and employing AERMOD software. The results of this study indicated that the concentration levels and types of pollutants are highly correlated with wind components. Therefore, modeling the behavior of pollutants while considering wind behavior at different hours, months, and seasons can be a suitable tool for analyzing and predicting the dispersion of pollutants from the copper smelting factory in the Khatoonabad plain. The maximum concentration of total particulate matterin this model was estimated at 0.37 µg/m³. based on the modeling results, the highest accumulation of pollution was recorded in the northeastern and southwestern sections of the factory. To validate the existing numerical model, the results obtained from the modeling were compared with the chemical analysis results of the soil in the Khatoonabad plain from previous studies. This comparison indicated a satisfactory agreement of the results.

Purpose of investigation

- **Estimation of air pollution levels due to the emission of pollutants from the stack of the Khatonabad melting factory**
- **Achieving an air pollution emission pattern considering wind direction during different hours of the day, months, and various seasons of the year.**

Study area

The study area of the Khatunabad Plain is located in the southeast of Shahrebabak County in Kerman Province, Iran. This area is situated at geographic coordinates of 55°15'61.0" to 55°48'32.0" longitude and 29°55'66.0" to 30°38'95.0" latitude (in the WGS-84 coordinate system). The Khatunabad Plain covers an area of 3841 square kilometers within the Abarkuh-Sirjan watershed. The elevation of the Khatunabad Plain ranges from 1853 meters to 2466 meters above sea level.

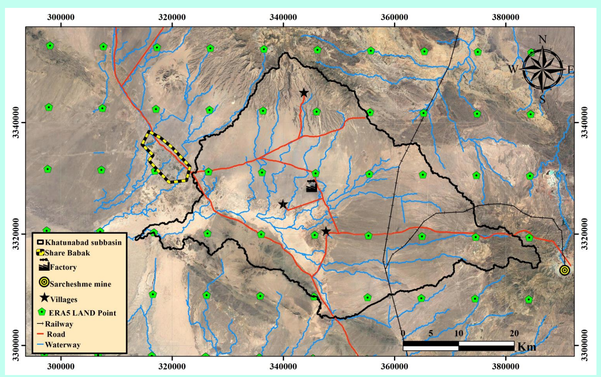

Fig. 1 – Map of the study area and the watershed of the Khatonabad plain, along with access routes.

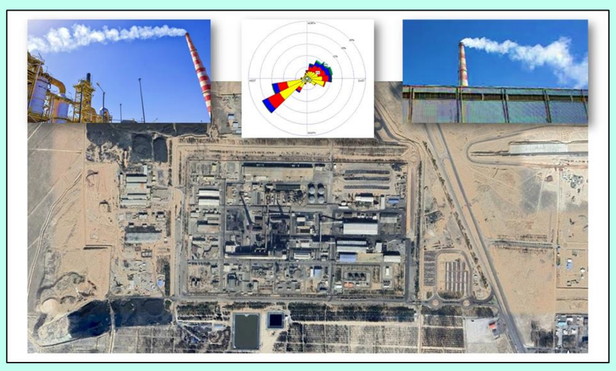

Fig. 2 - Behavior of dust emissions from the factory stack under the influence of wind.

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results

The wind components, particle size, and concentration of pollutants are among the most significant factors influencing the dispersion of pollutants. Therefore, in this study, the behavior and concentration of pollutants in the Khatunabad Plain have been examined and modeled by varying each of these parameters.

TPM pollutant in Khatunabad plain

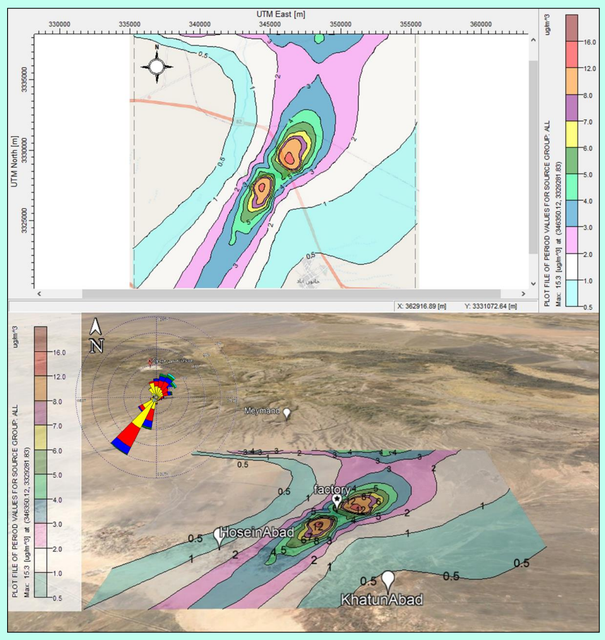

Fig. 3 - The dispersion of Total Particulate Matter (TPM) in the Khatunabad Plain (before the modification of electrostatic filters).

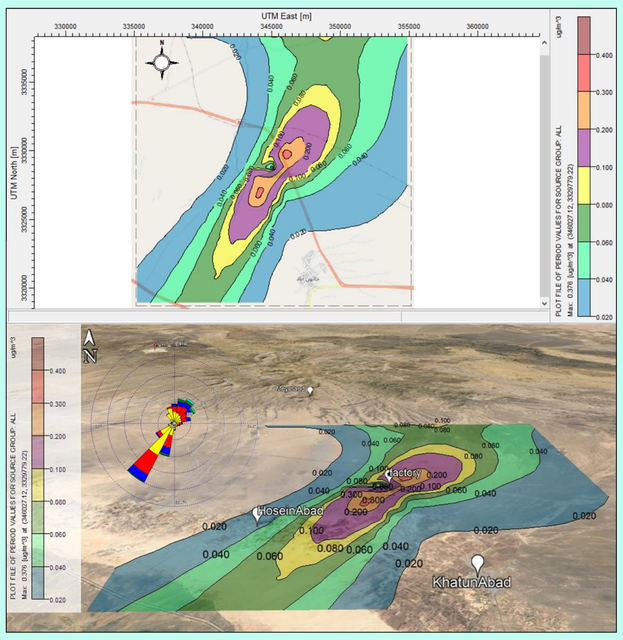

Fig. 4 - The dispersion of Total Particulate Matter (TPM) in the Khatunabad Plain (after the modification of electrostatic filters).

Modeling of TPM dispersion during different hours of the day

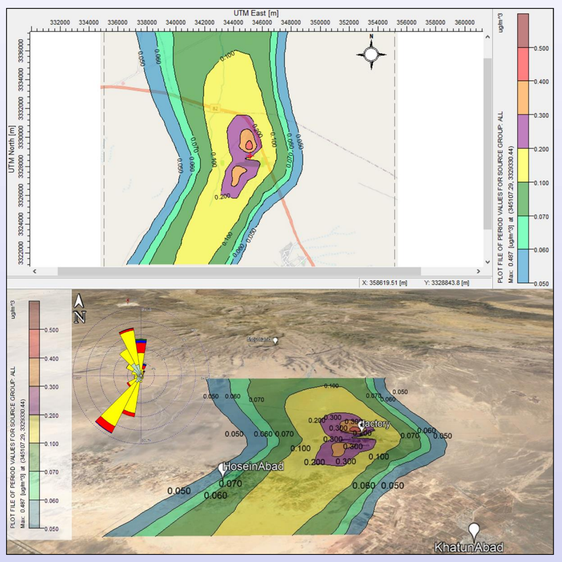

Fig. 5 – The dispersion of Total Particulate Matter in the Khatunabad Plain (from 00:00 to 03:00 hours).

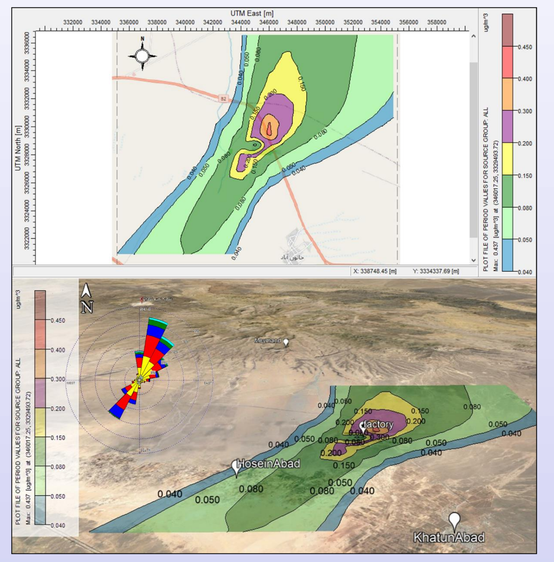

Fig. 6 – The dispersion of Total Particulate Matter in the Khatunabad Plain (from 06:00 to 09:00 hours).

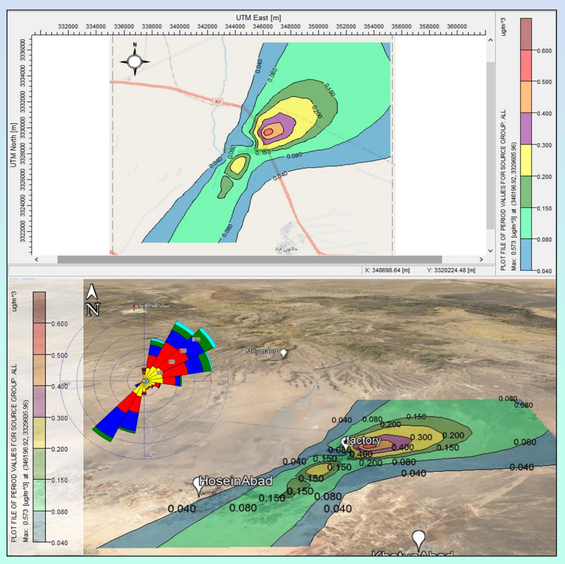

Fig. 7 – The dispersion of Total Particulate Matter in the Khatunabad Plain (from 12:00 to 15:00 hours).

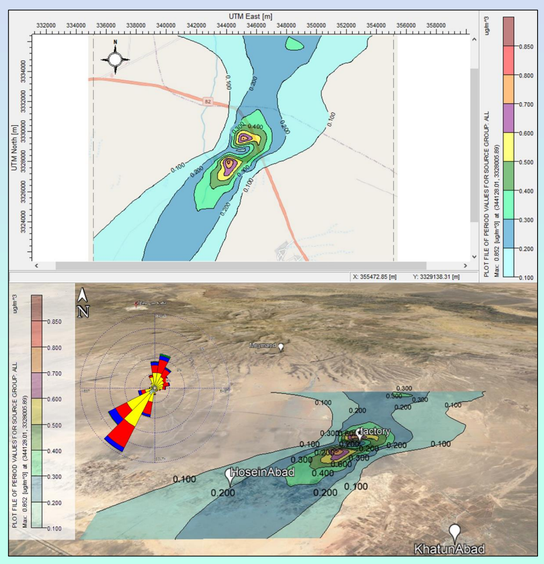

Fig. 8 – The dispersion of Total Particulate Matter in the Khatunabad Plain (from 18:00 to 21:00 hours).

Modeling of TPM dispersion in different seasons of the year.

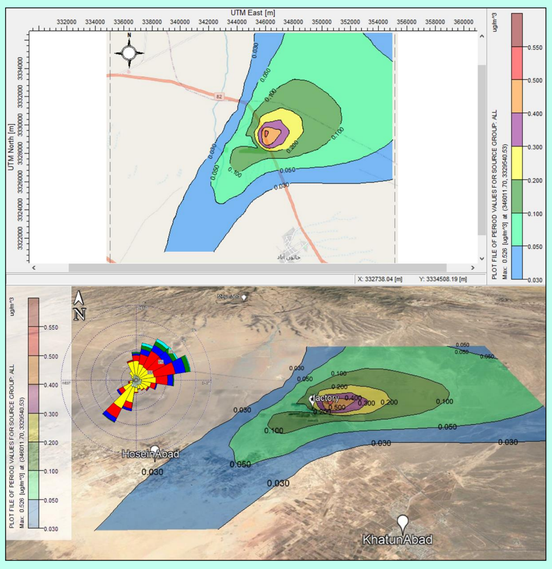

Fig. 9 – The dispersion of Total Particulate Matter in the Khatunabad Plain in spring.

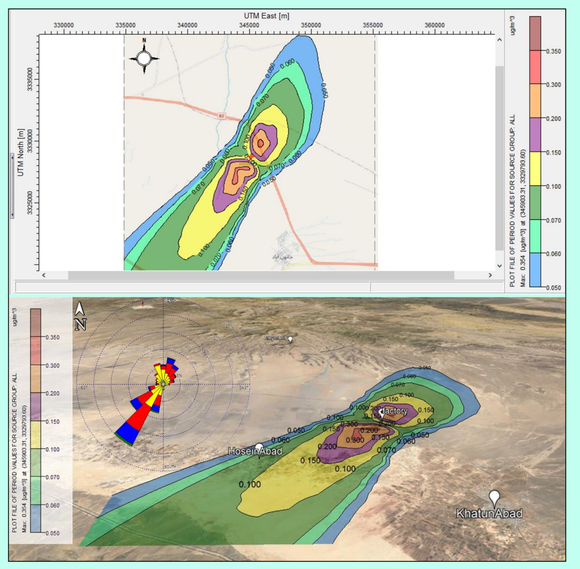

Fig. 10 – The dispersion of Total Particulate Matter in the Khatunabad Plain in summer.

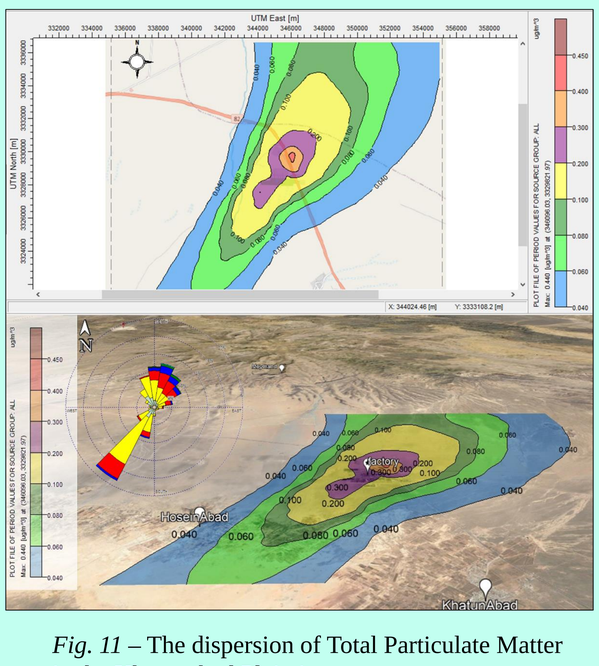

Fig. 11 – The dispersion of Total Particulate Matter in the Khatunabad Plain in autumn.

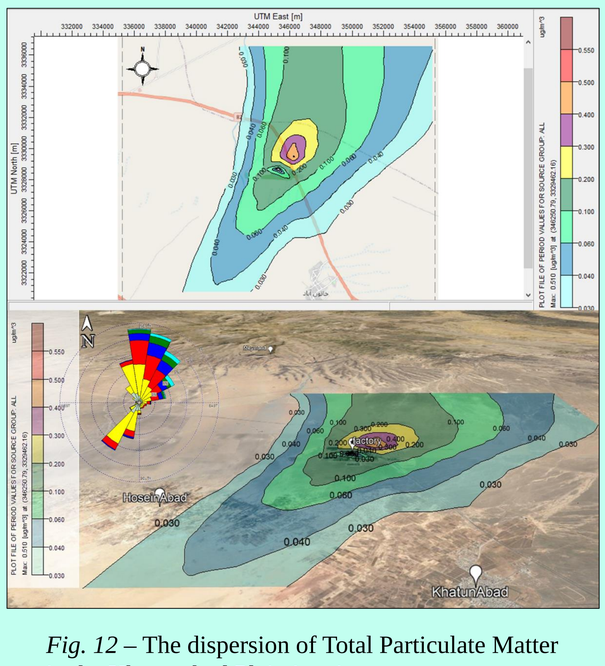

Fig. 12 – The dispersion of Total Particulate Matter in the Khatunabad Plain in winter.

Conclusions

- **Based on the results of dust modeling, the amount of dust produced from the Khatonabad melting factory's stack has a significant impact on the levels of pollutants released in the Khatonabad area. The modifications made at this factory to improve the capture of dust particles have notably influenced the improvement of pollutant dispersion in the Khatonabad region.**
- **Based on the results of pollutant dispersion modeling, the dispersion of pollutants is significantly influenced by wind behavior. Considering the speed and direction of the wind during specific time intervals allows for better decision-making regarding the optimal timing for operating the stacks of the Khatonabad melting factory.**
- **Particle size has a significant impact on the behavior of pollutant dispersion, such that finer particles are less influenced by wind behavior.**
- **According to the modeling results, the northeastern and southwestern sections of the factory exhibit the highest levels of pollution accumulation. Considering the high-speed winds blowing towards the northeast, some areas on the eastern slopes of the northern highlands of the Khatonabad plain are also found to be polluted.**