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Seasonal Variations in Pollutant Concentrations and Ecological Risk Assessment of Heavy Metals in Atmospheric Dust of Yazd City

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ABSTRACT

Dust deposition is widespread in arid and semi-arid regions worldwide. Because of Yazd is one of the industrial cities of Iran, where there are various steel, tile, and ceramic factories and industries around it. This study was conducted to investigate heavy element pollution in the atmospheric dust of Yazd city. Dust samples were collected seasonally from the fall of 2017 to the summer of 2018 at 30 locations, using sediment traps placed on the roofs of single-story buildings. Determination of the concentration of heavy elements and evaluation of indicators of heavy metal pollution, including the Geo-Accumulation Index (Igeo), the Integrated Nemerow Pollution Index (INPI), the Integrated Pollution Index (IPI), and the Modified Ecological Risk Index (MRI), to assess the level and extent of environmental pollution and dust were calculated in the area. According to the cumulative pollution index results, the fall and winter seasons had a high pollution index, and the spring and summer seasons had an average amount of pollution. According to the Nimru comprehensive pollution index, arsenic, cadmium, and zinc are in the heavy pollution class, with average values of 7.8, 3.7, and 6.9, respectively. The average values of the accumulation indices were Zn>Cr>Cu>Pb>As>Co>Fe>Ni>Mn>Cd. The modified ecological risk index results were between 300 and 600 in all seasons; therefore, the region was placed in the category of considerable ecological risk.

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INTRODUCTION

Dust storms are a significant phenomenon in arid and semi-arid regions worldwide, representing a major environmental challenge. More than two-thirds of Iran's land area lies within arid and semi-arid climatic conditions due to various factors, including geographical location and distance from large water bodies. Limited rainfall has somewhat reduced water erosion. However, the lack of vegetation covers and other factors conducive to soil erosion have created conditions for wind erosion and dust storms (Haghnazar et al., 2023; Soltani-Gerdefaramarzi et al., 2021). Atmospheric pollution is currently a major environmental challenge in many countries, and atmospheric dust, containing a wide range of chemical, organic, and inorganic compounds, is a significant atmospheric pollutant (Vaezi et al., 2024). Heavy metals are naturally occurring components of the Earth's crust (Al-Khashman, 2004) and are present in all ecosystems at varying concentrations. Several methods exist for determining and assessing the degree of heavy metal contamination in soil, sediments, and dust. Researchers categorize heavy metal pollution assessment indices into two main groups: individual indices and integrated indices (Qingjie et al., 2008). Dust storms are now a serious environmental problem in arid and semi-arid regions. Yazd, a major industrial city in Iran, is surrounded by steel and ceramic factories, and its atmosphere is frequently affected by dust storms. This research, given Yazd's geographical location characterized by surrounding arid and saline areas prone to dust storms and considering the city's industrial and traffic conditions, its position on the country's north-south highway, and the predicted high atmospheric concentrations of heavy metals, was undertaken. Therefore, determining the concentration of heavy metals in the city's atmospheric dust is crucial and can serve as an important step towards controlling atmospheric pollutants and ultimately improving the public health of the region's population.

DATA AND METHODS

This study was conducted in Yazd, the most populous city and capital of Yazd Province. Thirty sampling locations were randomly selected to ensure adequate coverage of the entire area for dust sampling. For atmospheric dust sampling, a bead-type dust collector consisting of a plastic tray with multiple rows of beads (at least two rows) was used. Atmospheric dust sampling was carried out in Yazd City at a height of three meters above ground level (on the rooftops of single-story houses) during the four seasons of autumn and winter 2018 and spring and summer 2019. Two types of sediment traps were used on each rooftop. Sediment samples were carefully collected at the end of each season, and transferred to the laboratory, and the traps were washed with water and reused after each sampling. After transferring the samples to the laboratory, all samples were first sieved through a 2-millimeter sieve to remove debris and then weighed. The dust samples were then digested using the four-acid method, and the concentrations of arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), Nickel (Ni), lead (Pb), and zinc (Zn) were measured, and heavy metal pollution assessment indices including the geo-accumulation index (Igeo), the Nemro pollution index (INPI), the pollution load index (IPI), and the modified risk index (MRI) were calculated to assess the level and extent of dust pollution in the area.

RESULTS AND DISCUSSION

Based on the results of the cumulative pollution index (IPI), the autumn and winter seasons fall into the third class and have a high pollution index, as the value of this index in these two seasons exceeded 2. Spring, with an average pollution index of 2, and summer, with an index less than 2, were ranked second with a moderate pollution level. The spatial distribution of this index also shows that the highest levels were found in the northwest and south of the region. The integrated pollution index (INPI) indicates that cobalt, with a seasonal average of 0.46, is in the unpolluted class; manganese, nickel, and chromium, with averages less than 1, are in the relatively unpolluted class. Iron, with an average of 1.6, has a slightly polluted class; copper and lead, with averages of 2.9 and 2.43 respectively, are in the moderately polluted class; and arsenic, cadmium, and zinc, with averages of

7.8, 3.7, and 6.9 respectively, are in the severely polluted class. The modified ecological risk index values ranged from 300 to 600 in all seasons, placing it in the category of significant ecological risk. The average index values for autumn, winter, spring, and summer were 405.70, 480.44, 395.71, and 377.71, respectively. Spatial analysis of this index at the regional level revealed that the western and southern areas of the study region exhibited higher ecological risk than other areas. Furthermore, the ecological risk factor (mEr) for heavy metals in dust samples from the study area, broken down by season, showed that manganese, nickel, chromium, zinc, and copper obtained values below 40, falling into class 1, or a low ecological risk level. Lead showed values between 40 and 80 in spring and summer, resulting in a classification of class 2, indicating a moderate ecological risk. Arsenic levels ranged from 80 to 160 in all four seasons, indicating a significant ecological risk. Cadmium, ranging from 160 to 320, presented a high ecological risk. The mean geo-accumulation index (Igeo) for heavy metals in the dust samples from the study area, broken down by season, was calculated as follows: arsenic 0.067, cadmium 0.617, cobalt 0.097, chromium 0.353, copper 0.287, iron 0.205, manganese 0.431, nickel 0.022, lead 0.096, and zinc 0.390.

CONCLUSION

This research showed that the concentration of some heavy metals, such as arsenic, lead, and cadmium, in the study area was higher than their average concentration in the soil. Spatial distribution mapping of the average concentration of heavy elements in dust during the four seasons studied showed that, except for arsenic and lead, the highest concentration of heavy metals was observed in the northwest and center of the city, decreasing eastward and southward. Traffic in the city center and proximity to industries located in the west and northwest of the area, along with the prevailing winds, are among the main factors affecting the concentration of heavy elements in dust in the northwestern parts of the study area. Investigation of atmospheric dust pollution in the region with heavy metals using various pollution assessment indices and the modified ecological risk index showed that the highest levels of heavy metal pollution occurred in autumn and winter, and the lowest in summer. Low temperatures and temperature inversions in the cold seasons, along with anthropogenic factors such as fossil fuel consumption and traffic, are among the reasons for the difference in heavy metal concentrations in different seasons. Based on the results of this research, preventing the movement of old, worn-out, and polluting vehicles and expanding the distribution and supply of high-quality fuel, which can significantly reduce the negative effects of traffic pollutants, is recommended. Furthermore, controlling pollutants emitted from industries located in the west and northwest of Yazd city increased sensitivity in monitoring pollutant levels, and seriously addressing polluting industries and compelling them to comply with environmental standards are among the most important strategies to reduce the negative effects and pollution from anthropogenic industrial factors, which are considered one of the main sources of heavy metal entry into the atmosphere.

REFERENCES

References (in English)

Al-Khashman O.A (2004). Heavy metal distribution in dust, street dust, and soils from the workplace in Karak Industrial Estate, Jordan. Atmospheric environment, 38(39):6803-6812.

Haghnazar, H., Soltani-Gerdefaramarzi, S., Ghasemi, M., Johannesson, K.H (2023). Receptor model-based approach to estimate urban road dust pollution by heavy metal (loid) exposed to desert dust storms in a rapidly growing city of Iran. Environmental Earth Sciences, 82(12), 316. https://doi.org/10.1007/s12665-023-11000-3.

Qingjie, G., D. Jun, X. Yunchuan, W. Qingfei, and X. Liqiang. (2008). Calculating pollution indices by heavy metals in ecological geochemistry assessment and a case study in parks of Beijing. J. China Univ. Geosci. 19: 230-241.

Soltani-Gerdefaramarzi, S., Ghasemi, M., Gheysouri, M., (2021). Pollution, human health risk assessment and spatial distribution of toxic metals in urban soil of Yazd City, Iran. Environmental Geochemistry and Health,43(9):3469-3484.

Vaezi, A., Shahbazi, R., Sheikh, M., Lak, R., Ahmadi, N., Kaskaoutis, D.G., Behrooz, R.D., Sotiropoulou, R.E.P. Tagaris, E., (2024). Environmental pollution and human health risks associated with atmospheric dust in Zabol City, Iran. Air Quality, Atmosphere & Health, pp.1-23. http://dx.doi.org/10.1007/s11869-024-01582-7.