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Original Article

Zoning of Dust Heavy Metals in Arak Plain Using Pollution Indicators and Geographic Information System (GIS)

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Abstract

Background: In regions with heightened pollutant concentrations, especially in industrial and urban areas, dust plays a crucial role in carrying complex metal components, posing environmental challenges and health risks. This study utilized pollution indicators and geographic information system (GIS) to delineate the spatial distribution of heavy metals in the Arak plain.

Methods: Dust samples from 30 stations across the Arak plain were systematically collected through random sampling. Analysis using inductively coupled plasma spectrometry (ICP-OES) allowed the calculation of pollution indices (PI) and the Nemerow Integrated Pollution Index (NIPI) for lead (Pb), zinc (Zn), copper (Cu), nickel (Ni), and iron (Fe). GIS generated spatial distribution maps depicting metal pollution.

Results: The average concentrations were 45.5 mg/kg for Pb, 10.7 mg/kg for Zn, 0.47 mg/kg for Cu, 30.8 mg/kg for Ni, and 0.206 mg/kg for Fe. Analysis of PI, NIPI, and spatial distribution maps revealed heightened pollution in the northeast, center, south, and southwest areas of the Arak plain, attributed to human activities like heavy vehicle traffic, high population density, concentrated agriculture, and specific industrial operations.

Conclusion: The study recommends mitigation strategies, including biological methods like phytoremediation, promotion of public transportation, mandatory environmental standards for industries, and encouragement of green practices. These initiatives aim to address and reduce environmental pollution in the Arak plain.

Keywords: Spatial distribution, Heavy metal, Integrated Nemerow Pollution Index (NIPI), Industrial capital of Iran

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Introduction

Atmospheric dust refers to the accumulation of solid particles, including organic and inorganic pollutants, on the Earth's surface in open spaces. It can be considered a valuable indicator for describing the quality of the urban environment.[1] Urban dust can originate from several sources, such as soil erosion, atmospheric sediments, and man-made activities like industrial operations, urban development, and traffic.[1,2] The chemical composition of atmospheric dust can be determined by factors such as tire and brake pad wear, gasoline combustion from car exhaust, oil lubricants, and the wear of colored pavement surfaces.[1,3] Urban dust serves as a significant reservoir for investigating the potential toxicity caused by metals and often leads to severe respiratory and skin complications in humans due to high metal levels.[4,5] Numerous studies have been conducted on the concentration and dispersion of metals, although few of these studies focus on developed countries.[6-8] Notably, Dytlow and colleagues conducted studies in 2021 that evaluated indicators such as contamination factor (C_f), enrichment factor (EF), geoaccumulation index (I_{geo}) and pollution load index (PLI) to assess metal pollution in street dust in Poland. The results of this research indicated high levels of metal contamination in street dust.[9] In another study conducted by Bisht and colleagues in 2022, the concentration of metals was investigated, and their distribution was analyzed using pollution indicators such as C_f, C_d, and PLI in urban road dust in Uttarakhand, the most populous city in the Indian state. The results of this research showed that the average concentration of manganese, zinc (Zn), copper (Cu), lead (Pb), iron (Fe) and nickel (Ni) metals was higher compared to the background values in India, with Pb and Zn identified as the most polluting elements in street dust. The central and eastern areas of the city were identified as the main centers of pollution due to the high volume of cars and population pressure.[10]

The objective of this study was to examine the concentration, spatial distribution, and pollution levels of Pb, Zn, Cu, Ni, and Fe metals in the dust of the Arak plain. To achieve this objective, the researchers utilized the Pollution Index (PI) and Nemerow Integrated Pollution Index (NIPI) to assess the pollution levels. Additionally, they employed geographical information system (GIS) technology to generate spatial distribution maps of the metals and pollution, based on the evaluated indicators.

Materials and Methods

Study Area

Arak city is located in the southwest of Tehran province, at a distance of 288 km. The city of Arak is situated at a latitude of 34 degrees, 5 minutes, and 30 seconds in the northern hemisphere from the equator, and at a longitude of 49 degrees, 41 minutes, and 30 seconds east of the Greenwich meridian. From a natural perspective, the current Arak plateau covers an area of 5400 km^2, with 2400 kilometers being the high plains of Arak and the remaining area consisting of the surrounding heights. The mountains in this region are formed by two mountain ranges.[11] The climate of Arak exhibits the climatic characteristics of the central plateau of Iran, with cold and wet winters and hot and dry summers. The mountains around Arak, Mighan Lake, and Farahan Plain have influenced the climate of this region and given it distinct characteristics.[12] The presence of various factories and industries in the area of Arak city, coupled with its central location within the province, has attracted industrial and service activities to Arak. Arak is recognized as one of Iran's industrial cities and holds the distinction of having the highest variety of industrial products, ranking second in terms of the presence of key industries, and serving as the fourth industrial hub of the country overall.[13] With the presence of key industries, such as the production of 80% of the country's energy equipment, the largest aluminum production plant, and the country's largest sodium sulfate mine, Arak has earned the title of Iran's industrial capital. However, due to the concentration of industries, Arak is also one of the most polluted cities in Iran. The combination of diverse industries and its status as the industrial capital of Iran contribute to its reputation.[14]

Research Methods

Sampling and Laboratory Analyses

Sampling was conducted using a combination of random selection and accessibility criteria at 30 stations. At each station, three repetitions of sampling were performed. The coordinates of the sampling points were recorded using a Geographic Positioning System (GPS) device. Once the sampling locations were determined, dust samples were collected and placed in amber glasses without using any metal tools. Pen brushes were utilized to collect the dust from the designated surfaces. Subsequently, the amber glasses were sealed with aluminum foil to prevent direct light exposure.[15] All the samples were passed through a 200 mesh sieve in the laboratory and stored in a refrigerator at a temperature of 4 °C until testing. The samples were prepared for analysis by dissolving four acids (HF, HCl, $HClO_4$, HNO_3).[1] After weighing the samples, 8 mL of 40% HF and 1 mL of 70% $HClO_4$ were added. The resulting solution was then placed in a special plastic container (HOT BOX) and heated in water up to a temperature of 200 °C until a gel solution was obtained. Grad was added to the solution. Subsequently, 3.75 mL of 37% HCl and 1.25 ml of 65% HNO_3 were added to the sample, and the solution was brought to a final volume of 25 mL. The metal concentration was measured using inductively coupled plasma spectrometry (ICP-OES) with a Varian 735 model device. Quality assurance (QA) and quality control (QC) were performed by measuring control samples and duplicate samples with an accuracy range of four to six percent.[1,15,16] For the measurement of metals using the ICP-OES device, the device was calibrated using standard solutions prepared by Merck, Germany, before analyzing the samples. The detection limits of the device for Pb, Zn, Cu, Ni, and Fe metals were 13.503, 1.501, 1.932, 11.639, and 126.015 mg/kg, respectively. The results were recovered within a range of 87-95%.

Statistical Analysis

The statistical analysis of the data was conducted using SPSS and Excel software. Initially, the normality of the data was assessed. Subsequently, a comparison of the metal concentrations measured in the soil samples at different stations was performed. Finally, the correlation of the data was examined.

Pollution Measurement Indicators

Pollution Index

This index was introduced by Hakanson in 1980, in which the average concentration of the measured element is compared with the amount of the same element in the reference area.[17,18] This index is calculated using Equation 1[17]:

$$PI = \frac{Ci}{Bi} \qquad (1)$$

In this regard, Ci is the concentration of the i-th pollutant, Bi is the base line concentration of the pollutant and PI is the pollution index of the i-th pollutant. In the present study, the average shale given by Wedephol and Turkian[17] was used to determine the amount of dust contamination with metals (Table 1).

The obtained values are interpreted with the help of the PI pollution index with the help of Table 2 and the intensity of the pollution is evaluated in the sampling stations (Table 2).

Table 1. Concentration of elements in average shale (mg/kg)[17]

Elements	Pb	Zn	Cu	Ni	Fe
Shale average	20	95	45	68	47.200

Table 2. Pollution index[17]

PI Value	Pollution Intensity
PI ≤ 1	No pollution
1 < PI ≤ 2	Low pollution
2 < PI ≤ 3	Moderate pollution
PI > 3	High pollution

PI, Pollution Index.

Nemerow Integrated Pollution Index

NIPI is expressed based on Equation 2[18]:

$$NIPI = \sqrt{\frac{PIi\max^2 + PIiave^2}{2}} \tag{2}$$

In this context, PIimax represents the highest PI value for each metal, while PIiave corresponds to the average PI value for each metal. The key advantage of this index, in comparison to other indices, is its ability to assess the contamination risk associated with all metals under investigation within the study area.[18] The comprehensive pollution index provided by NIPI can be interpreted using the accompanying table, allowing for the evaluation of pollution levels and warnings at the sampling stations (Table 3).

Software analysis (ArcGIS)

In this study, the distribution and status of pollution levels were investigated, and a pollution zoning map was created using the Geographic Information System (GIS). The interpolation method employed for this purpose was the image distance method (IDW).[15,19] The IDW method estimates values based on the weighted contributions of nearby points, with the weights determined by their distance from the target point. Unlike the kriging method, the IDW method does not rely on assumptions related to spatial relationships or have a variogram. Instead, it assumes that points closer to the origin point are more similar to it than points further away.[20,21] One interesting characteristic of the IDW method is that the weight assigned to each point decreases rapidly as the distance increases, resulting in a completely local interpolation. Since the weights are never zero, there are no discontinuities in the estimations. Typically, a power value is considered for the distance image, which is usually set between 1 and 5. However, a power of 2, representing the reciprocal of the square of the distance, is commonly used (Equation 3).[19,20]

$$W(x,y) = \sum_{i=1}^{n} \lambda_i w_i$$

$$\lambda_i = \frac{(\frac{1}{d_i})^p}{\sum_{i=1}^{N} (\frac{1}{d_k})^p} \tag{3}$$

Table 3. Nemerow Integrated Pollution Index[18]

NIPI Value	Pollution Level
NIPI ≤ 0.7	No pollution
0.7 < NIPI ≤ 1	Risk of pollution warning
1 < NIPI ≤ 2	Low pollution level
2 < NIPI ≤ 3	Average level of pollution
NIPI > 3	High level of pollution

NIPI, Nemerow Integrated Pollution Index.

In this relationship, W(x,y) are the estimated values at the position (x,y), N is the number of known points adjacent to (x,y), i λ is the weight assigned to each of the known values of Wi at the position (x,y), di is the euclidean distance between each of the points located at the positions (x,y) and P is the power value that is affected by the weight of Wi on W.[15,19,21]

Results and Discussion

Results Obtained From Sampling and Statistical Analysis

The statistical description of the data obtained from the metal concentration in the dust of Arak Plain is presented in Table 4. The average concentrations of Pb, Zn, Cu, Ni, and Fe metals in the study area were 45.460, 10.711, 46.991, 30.796, and 206.002 mg/kg, respectively. The highest average concentration was observed for Fe, while the lowest average concentration was found for Zn in the study area.

The results of the statistical analysis indicate that the data for Pb, Zn, Ni, and Fe metals are normally distributed ($P > 0.05$). For Cu metal, the data were normalized and then analyzed using Lune's test. All metals, except Cu, showed homogeneity ($P > 0.05$). Following the assessment of normality and homogeneity, the concentration of metals in soil samples from different stations was compared using the Duncan test for Pb, Zn, Ni, and Fe metals, and the Dunnett T3 test for Cu metal. The results of both tests revealed significant differences in the concentrations of the studied metals across most sampling stations. Furthermore, the correlation test results demonstrated a positive and significant correlation between the concentrations of Pb and Ni, Zn and Ni, Zn and Pb, and Zn and Fe, as well as between Ni and Pb, Ni and Zn, and Ni and Fe. These correlations were found to be significant at a probability level of 99%.

Results of Calculation of Pollution Measurement Indicators

The results of investigation and calculation of PI pollution index are shown in Table 5. The largest number of stations were found to be heavily polluted with Fe and the largest number of stations without Ni pollution.

The results of NIPI have been shown in Table 6. As can be seen, 60% of the samples studied had high level of pollution and the remaining (40%) had moderate pollution.

Table 4. Statistical Description of the Metal Concentration in the Dust of the Arak Plain (mg/kg)

Metal	Mean	Min	Max	Percentage Coefficient of Variation	Standard Deviation
Pb	45.460	19.383	106.783	40.222	18.285
Zn	10.711	2.960	100.580	161.451	17.294
Cu	46.991	4.883	287.313	122.143	57.396
Ni	30.796	16.777	45.777	24.056	7.408
Fe	206.002	140.907	295.507	21.519	44.330

Table 5. Evaluation Results of PI Pollution Index in Dust Samples in Arak Plain

	PI			Number of Samples			
Mean	Max	Min	Metals	No Pollution	Low Pollution	Moderate Pollution	High Pollution
Pb	0.969	5.339	2.273	1	13	13	3
Zn	0.031	1.059	0.113	29	1	0	0
Cu	0.109	6.385	1.044	22	3	3	2
Ni	0.247	0.673	0.453	30	0	0	0
Fe	2.985	6.261	4.364	0	0	2	28

PI, Pollution Index.

Table 6. Evaluation results of NIPI in dust samples in Arak plain

NIPI			Number of Samples				
Min	Max	Mean	No pollution	Risk of pollution warning	Low pollution level	Average level of pollution	High level of pollution
2.227	4.856	3.364	0	0	0	12 (40%)	18 (60%)

NIPI, Nemerow Integrated Pollution Index.

Software Analysis Results (ArcGIS)

The concentration distribution map of each metal in the dust samples of Arak Plain has been shown in Figure 1.

The distribution map of the PI value of each metal based on the classification provided in the PI pollution index for Arak plain dust samples has been shown in Figure 2.

The zoning map of NIPI of metals in Arak plain dust samples has also been shown in Figure 3.

The rapid development of human societies and the increase in industrial activities in the present era have resulted in the release of numerous pollutants into the atmosphere, leading to a worsening of pollution conditions. Dust and airborne particles, in particular, pose significant climatic and environmental hazards in arid and semi-arid regions. Additionally, the introduction of toxic elements like metals into the environment through dry atmospheric dust can have adverse effects on the biological and biogeochemical cycles of ecosystems.[22] The findings of the analysis of metal concentrations at polluted stations and their distribution have been summarized in Table 7.

The zoning results of the map illustrating the spatial distribution of metal concentrations in the dust of Arak Plain indicate that the southwestern side of Arak Plain exhibits high pollution levels compared to all the studied metals. This can be attributed to its proximity to Arak city's high population density, and the presence of shopping and office centers. Furthermore, factors such as urbanization, heavy traffic, the presence of large and polluting industries like the aluminum factory, machine building, combine making, aluminum roll, and the proximity to industrial poles number 1 and 2 of Arak and the Haji Abad industrial area contribute to the elevated pollution levels. These findings align with previous studies by Shojaei Shojaee Barjoee and colleagues in 2019, who assessed the ecological risk associated with metals found in dust emitted from non-metallic industries in Ardakan, Yazd. Their study revealed very high concentrations of Pb, Zn, and arsenic in the area, with pollution indices (PI, NIPI, C_f) indicating critical contamination.[23] Likewise, Aguilera and colleagues in 2021 evaluated metal pollution and health risks associated with street dust in Mexico. They observed high concentrations of Pb and chromium metals in the dust, prompting recommendations for implementing restrictions to control the existing conditions in the city.[24] In another study conducted in 2021, Heidari and colleagues investigated metal pollution in road dust and evaluated resulting health risks in Bandar Abbas city. They concluded that suburban roads exhibited higher levels of metal pollution in the dust compared to urban roads, with industrial and construction activities identified as the major contributors to this pollution.[25]

Overall, these studies support the findings of the present study, highlighting the significance of metal pollution in dust and its associated environmental and health implications.

The element distribution map was created using geographic information system (ArcGIS) and the pollution indices PI and NIPI. Table 5 presents the results of the PI pollution index calculations for Pb, Zn, Cu, Ni, and Fe metals. The average PI index values for these metals were 2.273, 0.113, 1.044, 0.453, and 0.364, respectively.

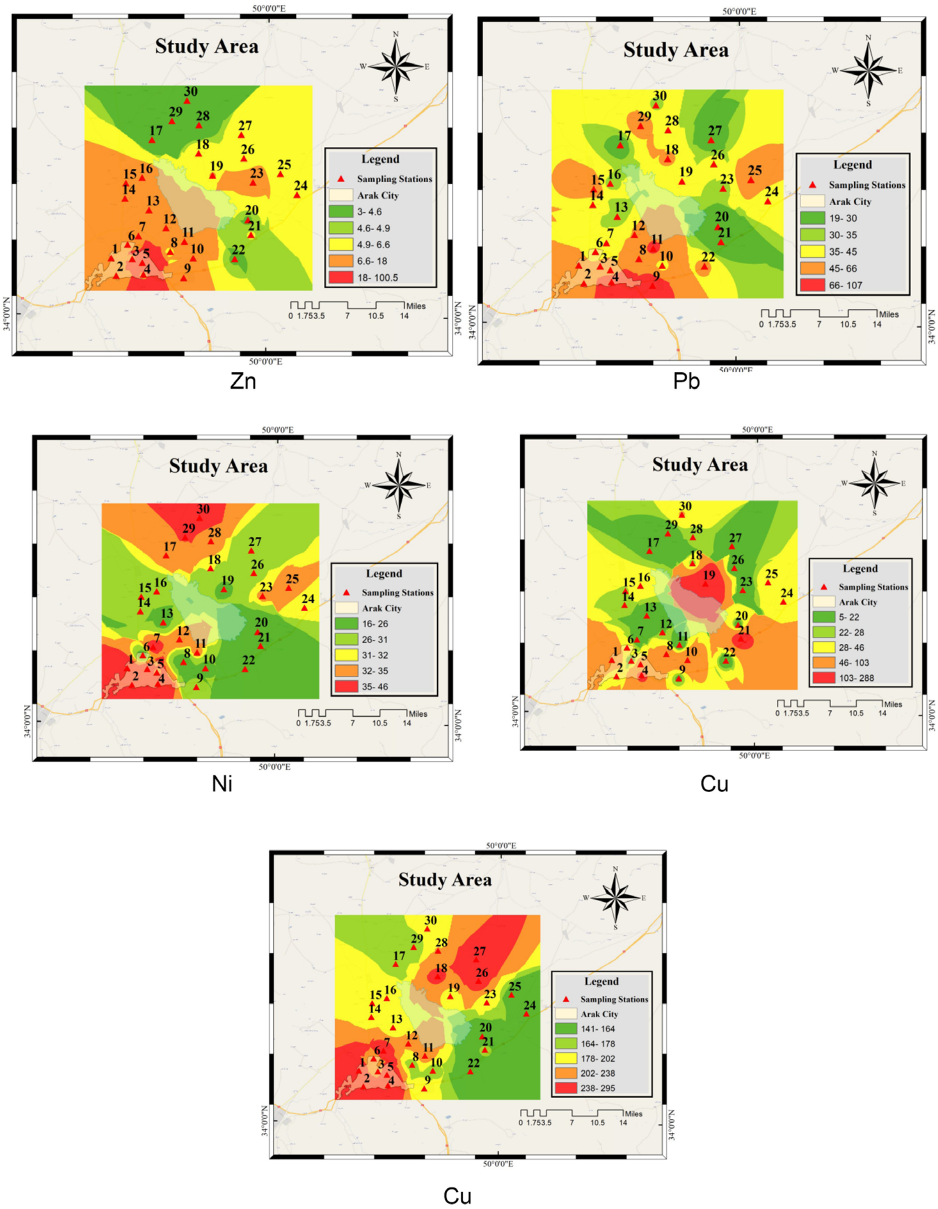

Figure 1. Spatial Distribution of Metal Concentration in the Dust of Arak Plain

The analysis of the PI values revealed that the pollution index varied for each metal. In terms of Pb, 96.7% of the samples exhibited high pollution (PI > 1). For Zn, only 3.34% of the samples showed high pollution levels, while 26.7% of the samples had high pollution levels for Cu. All samples were classified as contaminated (PI > 1) for Fe. However, all samples were found to have uncontaminated values (PI < 1) for Ni. Overall, the analysis of the PI index indicates that the dust in Arak Plain exhibits varying levels of pollution for Pb, Zn, Cu, and Fe metals. The highest level of pollution, as indicated by a PI value greater than 3, was observed for Fe metal. Based on the PI index, the intensity of pollution for the metals in the dust samples can be classified as follows: Fe > Pb > Cu > Zn > Ni.

Based on the zoning map of the PI pollution index for metals in dust samples (Figure 2), it is evident that Fe metal exhibits severe pollution in over 90% of the stations. This can be attributed to the presence of numerous industries, industrial hubs, urban and rural areas, high population density, heavy traffic (including the traffic of heavy vehicles), the presence of agricultural land, Arak airport, and the abundance of Fe elements in the earth's crust. The spatial distribution of pollution in terms of Pb metal, as depicted in Figure 2, indicates a heavy pollution layer in the southern and southwestern areas of Arak Plain. This can be attributed to the proximity of these areas to urban traffic zones, polluting factories, industrial hubs, Arak airport, and the Mineral Minerals Company of Iran. The intensity of pollution in these areas can be associated with these factors. Regarding Cu metal, severe pollution in terms of the PI pollution index was observed in the central area of Arak Plain, the northeastern side of Mighan wetland, and small portions of the southeastern and southwestern sides of Arak Plain. The presence of rural areas, agricultural activities, industrial factories, and the industrial areas of Khairabad and Aybakabad in these

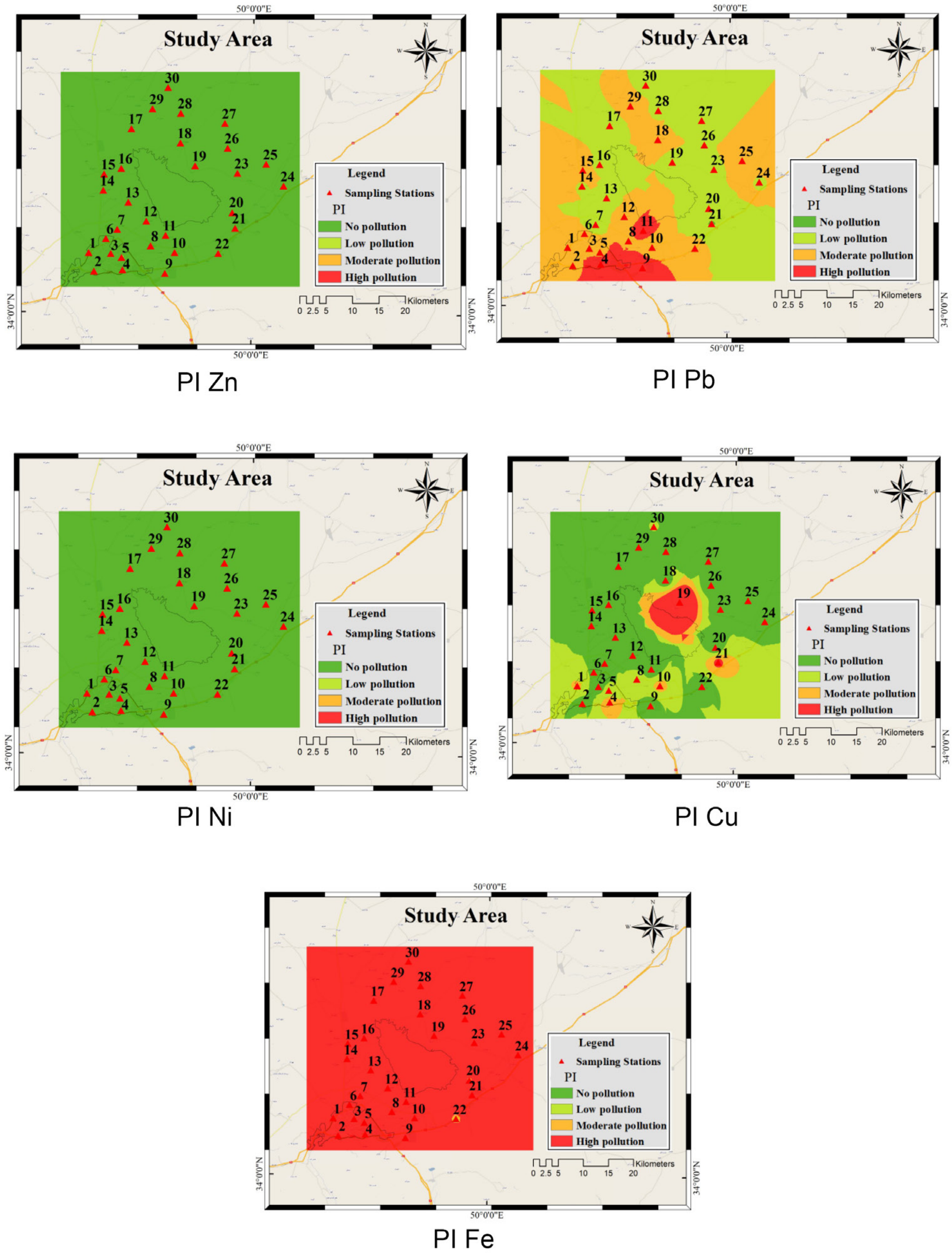

Figure 2. Zoning Map of PI of the Metals in the Dust of Arak Plain

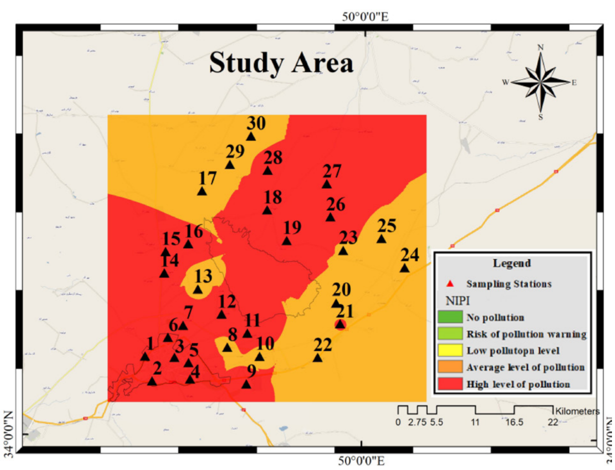

Figure 3. Zoning Map of NIPI of the Metals in the Dust of Arak Plain

locations can contribute to the intensity of pollution. In terms of Zn and Ni metals, more than 90% of the stations showed no contamination based on the PI pollution index (all stations for Ni metal and 29 stations for Zn metal). It should be noted that further studies are required to investigate the sources and reasons for pollution intensity at each specific point and for each metal in Arak Plain, as these aspects were not addressed in the current research. he findings of this study are in line with the results of previous research. For example, Sadeghdoost and colleagues in 2018 examined the C_f enrichment factor and the PI pollution index, as well as the sources of pollution for certain metals in the street dust of Dezful city. They concluded that Zn and Pb metals were highly polluted in that city.[18] Similarly, Luo and colleagues in 2022 measured metal pollution concentrations, conducted risk

Table 7. The Results of the Concentration of Elements in Polluted Stations and Their Distribution

Metals	Metal Concentration (mg/kg)	The Highest Metal Concentration Based on the Spatial Distribution Map (Figure 1)	Geographical Location of Polluted station	Use of Polluted Station
Pb	19.383-106.783	Stations 4, 9 and 11	South and southwest side of Arak plain	Proximity to aluminum factories, machinery manufacturing, combine manufacturing and Alumerol in station 4; proximity to industrial hubs No. 1 and 2, Haji Abad Industrial Zone, Arak city's southern ring road and the traffic of heavy vehicles with diesel fuel at station 9; proximity to Arak airport and Arak city treatment plant at station 11.
Zn	2.960-100.580	Stations 3, 4 and 5	Southwest side of Arak plain	Proximity to Arak city center and administrative and residential points, high volume of urban traffic and consequently high use of gasoline fuels and smoky vehicles, as well as high urban population density in station 3; proximity to Jat Aluminum Factory, Machine Manufacturing, Combine Manufacturing and Alumerol in Station 4; proximity to some existing factories in Arak city, such as Hepco Factory in station 5.
Cu	4.883-287.313	Stations 4, 19 and 21	Central, southeast and southwest sides of Arak plain	Proximity to aluminum factories, machinery manufacturing, combine manufacturing and Alumerol in station 4; proximity to some rural areas such as De Namak village and Mighan wetland at station 19; and proximity to Khairabad industrial area at station 21.
Ni	16.777-45.777	Stations 1,2,3,4,5,7,29 and 30	North and southwest side of Arak plain	Proximity to the cemetery of Arak city, proximity to the northern ring road of Arak city and the traffic of heavy vehicles with diesel fuel at station 1; حroximity to Gardo mountain and urban residential areas in Gardo residential area, urban traffic load, population density, shopping centers, proximity to the southern ring road of Arak city and traffic of heavy vehicles in station 2; Proximity to Arak city center and administrative and residential points, high volume of urban traffic and consequently high use of gasoline fuels and smoky vehicles, as well as high urban population density in station 3; proximity to existing factories in Arak city, such as the aluminum factory, machine factory, combine factory, and aluminum roll in station 4; Proximity to Hepco Factory at station 5; proximity to the residential area of Gavkhaneh and the northern bypass of Arak city and extensive intercity traffic from this bypass at station 7; proximity to the rural areas of Shams Abad and Khoshdoun and the existence of agricultural lands and rural areas in station 29; proximity to the rural area and agricultural lands of Taj Abad village and proximity to Farmahin industrial area at station 30.
Fe	140.907-295.507	Stations 1,2,4,5,7,18,26 and 27	Northeast and southwest side of Arak plain	Proximity to Arak city cemetery, proximity to the northern ring road of Arak city and vehicle traffic at station 1; proximity to Gardo mountain and urban residential areas in Gardo residential area, urban traffic load, population density, shopping centers, proximity to the southern ring road of Arak city and traffic of heavy vehicles in station 2; proximity to aluminum factories, machinery manufacturing, combine manufacturing and Alumerol in station 4; proximity to Hepco factory at station 5; proximity to the residential area of Gavkhaneh and the northern bypass of Arak city and extensive intercity traffic from this bypass at station 7; Proximity to rural areas and agricultural lands of Dawood Abad, Cheshme and Dastjard villages in stations 18, 26 and 27 respectively.

assessments, and studied the PI, PLI, and EF pollution indices in dust storms in northwestern cities of China. They found that Cu and Ni metals primarily originated from industrial sources, including local mines, while chromium metals were mainly associated with industrial production activities such as coal combustion. Lead and Zn metals were primarily attributed to production and transportation sources, and Ti, V, Mn, Fe, and As metals were derived from natural and agricultural sources.[26]

The results of calculating and zoning the NIPI indicated that polluted areas in Arak Plain are primarily associated with human activities. These activities include the presence of numerous industrial factories emitting pollutants, urban beltways with heavy traffic from vehicles, urban areas with high population density and heavy traffic, agricultural activities in concentrated areas such as Point A village, and the presence of Arak airport and an urban treatment plant. These highly polluted points are distributed across the northeast, central, south, and southwest areas of Arak Plain. A study conducted by Qanawati and colleagues in 2017 examined the concentration of metals in the street dust of Ahvaz city using the PI and NIPI pollution indicators. They observed high levels of metal concentration in the street dust, especially in areas with high population density and heavy traffic, indicating severe pollution from these toxic metals.[6] Similarly, in 2021, Hojjati assessed the origin and pollution status of street dust in Ahvaz city with certain metals using the PI and NIPI pollution indicators. The study found that the street dust in Ahvaz city exhibited high pollution levels for metals, primarily attributed to human activities. Lead, Zn, and Cu metals were identified as originating mainly from human sources.[27] Yomi-Agbajor and Gbadebo in 2021 assessed the health risk, pollution indicators, and ecological risk of metals in dust and soil samples from Warri metropolis in southern Nigeria. The study concluded that silver metal exhibited high pollution levels, while Pb and Zn showed relatively lower pollution levels. The NIPI index also indicated higher pollution levels in the dust samples from the Ekpan road sampling site compared to other sampling points.[28] Another study conducted by Haque and colleagues in 2022 evaluated the environmental and health risks associated with toxic metals in the dust of roads and highways in the capital of Bangladesh. They used various indices, including I_{geo}, NIPI, PI, Potential Ecological Risk Index (PERI), and Integrated Risk Index (NIRI). The study revealed severe pollution in many sampling sites, primarily attributed to local environmental factors.[29] These studies provide additional evidence of the impact of human activities on metal pollution in various regions, highlighting the importance of pollution indices in assessing and understanding the sources and levels of pollution.

Conclusion

Finally, based on the results of this study, suggestions can be made to reduce the level of metal pollution in the Arak plain, such as increasing green spaces in places with high traffic loads, using biological reduction with the help of plants (phytoremediation), converting liquid fuels into gas., using public transportation, requiring industries to locate properly and away from residential and urban areas, requiring industries to obtain environmental ISOs (ISO 14001), encouraging industries to become a green industry, reviewing the Mighan Wetland Eligibility Plan, and etc. Finally, it is suggested that in line with this study, other studies should be carried out by other researchers in order to determine the origin of metals in the dust of the plain and the city of Arak in the future.

Authors' Contribution

Conceptualization: Samar Mortazavi, Alireza Riyahi Bakhtiari.
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Funding acquisition: Faezeh Saberinasab, Samar Mortazavi, Alireza Riyahi Bakhtiari.
Investigation: Faezeh Saberinasab, Samar Mortazavi, Alireza Riyahi Bakhtiari.
Methodology: Faezeh Saberinasab, Samar Mortazavi.
Project administration: Samar Mortazavi.
Resources: Faezeh Saberinasab, Samar Mortazavi, Alireza Riyahi Bakhtiari.
Software: Faezeh Saberinasab.
Supervision: Samar Mortazavi, Alireza Riyahi Bakhtiari.
Validation: Samar Mortazavi, Alireza Riyahi Bakhtiari.
Visualization: Faezeh Saberinasab, Samar Mortazavi**.**
Writing–original draft: Faezeh Saberinasab, Samar Mortazavi.
Writing–review & editing: Samar Mortazavi, Alireza Riyahi Bakhtiari.

Competing Interests

The authors declare no competing interests.

Data Availability Statement

The data are available upon request.

Ethical Approval

All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them.

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