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Assessment of Heavy Metal Pollution Levels and Spatial Distribution in Road Dust (A Case Study in Health Centers of Yazd City)

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ABSTRACT

The increase in pollution resulting from industrialization and urbanization has become an important concern in developing countries owing to its impact on human health. Therefore, in the present study, to investigate the pollution, 70 street dust samples were collected from medical centers in Yazd and in the laboratory to determine the content of Fe, Co, Mn, Zn, Pb, Cr, Cd, Ni, Cu, As and Al was digested using induction spectroscopy. The spatial pattern of the metal concentration was prepared using the Inverse Distance Weighted (IDW) interpolation method in GIS software. Pairwise correlation between metals was performed using Pearson's correlation, and classification of similar metals in terms of possible origin was performed using hierarchical clustering. In addition, the pollution level was determined using the enrichment factor, geo-accumulation index, pollution index, and integrated pollution index. According to the results, the trend of the average concentration of metals is Fe (23587.16), Al (18074.94), Zn (602.54 mg/kg), Mn (445.7 mg/kg), Pb (80.95 mg/kg), Cu (60.86 mg/kg), Cr (46.83 mg/kg), Ni (34.09 mg/kg), Co (10.2 mg/kg), As (0.29 mg/kg), and Cd (0.21 mg/kg). Based on the spatial distribution pattern, the highest concentrations of metals were observed in medical centers near the two-way street and single-line station. The highest amount of enrichment was observed for Zn, and as a result, a class of high enrichment was observed. The highest values of the soil accumulation index, degree of pollution, and uniform pollution were related to Zn and Pb. A significant correlation was observed between-Al and Fe Co–Mn Cr, Cd-Cr-Pb, and Ni-Cu elements at the 1% level, while As did not correlate with other elements. Based on the hierarchical clustering of elements, Co, Mn, Cr, Cd, Pb, Ni, Cu, and Zn were of human origin, while Al and Fe were of natural origin.

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INTRODUCTION

Rapid urbanization and industrialization are two major factors that lead to increased consumption of resources, energy, and consequently, pollution (Yang et al., 2014). These factors play a significant role in increasing heavy metals and are considered the main sources of heavy metals in the urban environment (Sojuka and Jascola, 2022). Dust particles are considered a significant indicator for describing urban environmental quality, which includes the accumulation of solid particles on external surfaces (Roy et al., 2022). A large part of Iran is covered by desert and semi-desert areas. Yazd, one of the central cities of Iran, experiences frequent dust storms. Over the past decade, many studies have been conducted to measure the concentration of heavy metals in industrial areas and natural areas of Yazd province, but no studies have been conducted in this regard in healthcare centres of the provincial capital. These centres, as the first level of service providers in the city, are responsible for providing health services to people. Therefore, maintaining environmental hygiene can play a significant role in preventing and spreading diseases among staff and visitors. Considering the importance of this issue, the main objectives of this study are to assess the potential of heavy metal contamination, spatial distribution, and their probable sources in the healthcare centres of Yazd city.

DATA AND METHODS

Yazd, due to industrialization and immigration, is one of the rapidly growing cities in Iran. In recent years, various industries such as tiles, ceramics, textiles, steel, and mining have significantly increased. In this study, dust samples were collected from 70 healthcare centres in Yazd County. After digestion of the samples in the laboratory, the concentration of heavy metals was measured using inductively coupled plasma spectroscopy. The spatial distribution of heavy metal concentrations was determined using the inverse distance weighted (IDW) method. Pearson correlation and hierarchical cluster analysis were used to determine the potential source and grouping of heavy metals, respectively. The pollution level was assessed using the enrichment factor (Yongming et al., 2006), geo-accumulation index (Muller, 1969), and degree of contamination index (Yilmaz-Abanuz, 2011).

RESULTS AND DISCUSSION

The average concentrations of metals were estimated as follows (in mg/kg): iron (23587.16), aluminium (18074.94), zinc (602.54), manganese (445.07), lead (80.95), copper (60.86), chromium (46.83), nickel (34.09), cobalt (10.02), arsenic (0.29), and cadmium (0.21). Based on the spatial distribution pattern, the highest concentrations of metals were observed in healthcare centres located near two-way streets and bus stations. The highest enrichment factor was observed for zinc, resulting in a high enrichment class. Additionally, the highest values of the geo-accumulation index, contamination degree, and pollution load index were also related to zinc and lead. A significant correlation was found between aluminum-iron-cobalt-manganese-chromium, cadmium-chromium-lead, and nickel-copper at the 1% level, while arsenic showed no correlation with other elements. Based on hierarchical clustering, cobalt, manganese, chromium, cadmium, lead, nickel, copper, and zinc had an anthropogenic origin, while aluminium and iron had a natural origin.

CONCLUSION

Except for iron, arsenic, and aluminium, the concentrations of other elements in healthcare centres of Yazd City were higher than the background levels, indicating the significant impact of human activities on their increase. Based on hierarchical cluster analysis, iron and aluminium were grouped, suggesting a natural origin, while cobalt, manganese, chromium, cadmium, lead, nickel, copper, and zinc were grouped, indicating an anthropogenic origin. According to Lu et al. (2009), elements such as copper, zinc, lead, and manganese originate from urban traffic and human activities, which is consistent with the findings of this study. The high enrichment factors of 29.96 and 3.8 for zinc and

lead, respectively, which have similar anthropogenic origins, indicate that human sources, especially traffic, are the most important factors contributing to dust pollution. Based on the Igeo index, the studied metals were classified as unpolluted to moderately polluted. Overall, the contamination degree index for the 11 studied elements was 15.65, indicating a very high degree of pollution in Yazd city. The pollution load index values of 6.34 and 4.05 for zinc and lead, respectively, indicated a high level of pollution for these elements. Therefore, based on the above indices, the pollution of zinc and lead in Yazd city is alarming. Similarly, in a similar study by Haghnegar et al. (2023), it was reported that lead and zinc accounted for the highest amounts of metals in Yazd city. The results of this study can be effective in developing management approaches to reduce pollution. Additionally, the findings of this study can be useful for decision-makers and provide valuable insights for controlling and improving sources of heavy metal pollution.

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