Source and Health Risk Assessment of Potentially Toxic Elements in the Un-engineered Landfills Soil of Kermanshah Province

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Extended Abstract

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Introduction

The presence of potentially toxic elements in the environment and especially in soil has been one of the greatest concerns due to their health implications. Potentially toxic elements from anthropogenic sources tend to be more mobile than those from lithogenic or pedogenic sources. Generally, the distribution of potentially toxic elements is influenced by the nature of parent materials, climatic conditions, and their relative mobility depending on soil parameters, such as mineralogy, texture and class of soil. In the inhabited, and industrial areas, vicinity to the un-engineered landfills, excess accumulation of toxic elements in surface soils can directly threaten wellbeing of exposed inhabitants via ingestion, inhalation and dermal contact routes. A few studies conducted on risk assessment of potentially toxic elements in soils of Kermanshah province, west of Iran. Soil in the study area is susceptible to contamination by anthropogenic activities in the form of industrial wastewater, agricultural activities, solid waste, runoff, atmospheric deposition and especially un-engineered landfills. The presence of toxic elements in soil around of un-engineered landfills without proper consideration to the environmental protection measures, will certainly lead to a significant environmental hazard in Kermanshah province. Therefore, the main purposes of this study are to evaluate the contamination levels, health risk assessment, and source identification of As, Cd, Cr, Cu, Ni, Pb and Zn in the Gasre Shirin, Gilane Gharb, Paveh, Javanrood, Eslamshahr, Ravansar, Kermanshah and Sanghar un-engineered landfills.

Material and methods

A total of 30 topsoil samples were collected (0-20 cm depth) from the eight **un-engineered landfills** of the Kermanshah province. In order to achieve a representative sample, composite samples were prepared by mixing the four subsamples taken at each corners of 2×2 m square cell because composite sampling yields homogenized samples for analyses. The subsamples were mixed and a final sample of 1 kg was taken by repeated coning and quartering. To determine background concentration of heavy metals, eight soil samples were collected from areas far from known sources of contamination (40-60 cm depth).

The collected samples were immediately stored in polyethylene bags and air-dried in the laboratory at room temperature. Then, samples passed through a 2mm stainless steel sieve. The <2mm fraction was ground in an agate mortar and pestle and passed through a 63 micron sieve. In order to determine the concentration of As, Cd, Cr, Cu, Ni, Pb and Zn complete dissolution of soil samples (approximately 1 g of each) was carried out using a mixture of HF, HNO_3, $HClO_4$ and H_2O_2 in a Teflon beaker on sand bath at atmospheric pressure. The concentrations of the selected elements were measured by an accredited commercial laboratory (Zar Azma Laboratory, Iran) using ICP-MS methods. Data quality was ensured through the use of internal duplicates, blanks, and HRM. The precision and accuracy of measurements are 95% and +/-5% respectively.

The assessment of soil contamination was carried out using geochemical indices including contamination factor (CF), modified degree of contamination (mC_d) and enrichment factor (EF). The methodology used for the health risk assessment was based on the guidelines and Exposure Factors Handbook of US Environmental Protection Agency. The average daily doses (ADDs) of heavy metals received through ingestion, inhalation, and dermal contact for both adults and children were calculated. In this study, hazard quotient (HQ), hazard index (HI) and carcinogenic risk (RI) methods were used to estimate non-carcinogenic and carcinogenic effects of heavy metals.

The HQ was calculated by subdividing ADD of a heavy metal to its reference dose (RfD) for the same exposure pathway(s). If the ADD exceeds the RfD, HQ>1, it is likely that there will be adverse health effects, whereas if the ADD is less than the RfD, HQ<1, it is considered that there will be no adverse health effects. A hazard index (HI), the sum of HQs, which means the total risk of non- carcinogenic element via three exposure pathways for single element of <1 indicates no adverse health effects, while HI values >1 show possible adverse health effects. Carcinogenic risk is regarded as the probability of an individual developing any type of cancer in the whole life time due to exposure to carcinogenic hazards and was calculated for As and Cd as follows:

$$\text{Risk}(RI) = \sum_{i=1}^{n} ADD \times SF \tag{1}$$

The value of SF represents the probability of developing cancer per unit exposure level of mg/kg day. The acceptable risk range for carcinogens is set to 10^{-6} to by the USEPA, so that RI values below 10^{-6} do not require further action, while risks greater than 10^{-4} are considered to be of concern and require additional action to reduce the exposure and resulting risk.

Results and discussion

The soil pH ranges from 7.01 to 8.06, with an average value of 7.51 suggesting neutral conditions. Organic carbon (OC) contents of soil samples ranged from 0.06% to 4.91% (average 1.59%). In this study, based on the USDA textural triangle the main soil textures are loamy, clay loam and sandy loam, respectively.

The average abundance order of selected elements content is: Zn>Ni>Pb>Cr>Cu>As>Cd. Comparison of mean concentration of the potentially toxic elements in the soil samples with mean worldwide values reveals higher Zn, Pb and Ni contents in this area.

The results of contamination factor indicate very high contamination for Cd, Cu, Pb and Zn. Modified Degree of Contamination (mCd) calculated based on background values proves very high degrees of contamination for selected trace elements in Gasre Shirin and Eslamshahr landfills soil samples

The results of enrichment factor evaluation similarity to contamination factor indicate that Cd, Cr, Pb, Cu and Zn have more influence from anthropogenic sources. The maximum EF of Pb, Zn and Cd and Cu is 346.7,124 and 51.9 respectively, which means very high enrichment in Ghasre Shirin landfill soil samples.

Exposure doses of 7 heavy metals in soil samples of un-enggenerd landfills for children and adults were calculated. The total exposure HQs calculated based on adults from ingestion, dermal contact, and inhalation for Cd, Cu, Ni, Zn, As and Pb was less than 1(except Ghasreshirin landfill). The hazard quotient values based on the adult risk for Cr were greater than 1.0. The results show that HQ for Pb and As in children by dermal and ingestion pathway is exceeded 1.0 in soil samples of Paveh, Javanrood, Ravansar, Kermanshah and Sangher landfills and Ghasreshirin and Eslamshahr landfills, respectively.

Conclusion

The concentration, pollution level, potential sources and health risk of potentially toxic elements in eight landfills top soil of Kermanshah province were investigated in this study. The following conclusions were drawn from this research.

- Compared with the background values of As, Cd, Cr, Cu, Ni, Pb and Zn in soils of Kermanshah Province, landfills soil have elevated metal concentrations as a whole.
- According to high contamination level and health risk of some studied potentially toxic elements, and also due to the proximity of contamination sources to residential district of the study area, more attention should be paid to manage and reduce contamination.
- These results provide basic information of toxic elements pollution control and environment management in the area.

Keywords: Soil, health risk, source, landfill, Kermanshah, Iran

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