Evaluation of Soil Contamination by Heavy Metals around Fasa-Darab Road

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Received: 26 February 2020
Accepted: 29 July 2020

1. Introduction

Automobiles are generally one of the major sources of heavy metal pollutants in roadside sediments that enter the environment as particles from the exhaust or other components of the vehicle and pollute the soil and vegetation of these areas (Van Bohemen, 2003). The most common heavy metals in vehicles on the road are Cd, Cu, Pb, Ni and Zn (Elik, 2003; Li, 2001). These heavy metals have a toxic effect on the human body and cause many complications such as blood, nervous and bone diseases (Sarkar, 2002). So, in this study, the amount of heavy metal changes in sediments of road margins Darab-Fasa road was investigated. Al-Chalabi and Hawker (2000) collected samples from three-site soil in Brisbane, Australia, and studied the distribution of Pb around roads. The results showed that vehicle traffic was the main source of pollution, and in areas with more stable climatic conditions, the distribution of Pb in soil was significantly reduced by increasing the distance from the road. The study also found that Pb is accumulated in the first five cms of soil depth. Fakayode and Owolabi-Olu (2003) studied the soil contamination of the streets of Osgbo, Nigeria. By selecting 39 sites with different traffic volumes, they measured the distribution of zinc, nickel, copper, cadmium and lead metals at distances of 5, 15, 30 and 50 meters from the streets. The results showed that with increasing distance from the streets (distance of 50 meters), the concentration of soil metals decreases. Given the importance of the subject, this study investigates the soil contamination to heavy metals in the margins of Darab-Fasa road. In this study, the effect of distance to gas station and its effect on soil pollution was investigated. For this purpose, index of mular and contamination factor (CF), ecological risk index (RI), tolerance contamination index (PLI) were calculated and measured.

2. Study Area

The study area is located in the south of Fars province (Darab-Fasa road) at a geographical location of 28 ° 36′-28 ° 54′ N and 53 ° 36′ - 54 ° 30′ E. Fasa-Darab road with a length of about 100 km has long been considered as the main road connecting Shiraz (Iran's largest city in the southern half of the country) to Bandar Abbas (Iran's largest commercial

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port). This road has always been used by a variety of light and heavy cars. The cities of Fasa and Darab are the most important demographic centers in the southeast of Fars province, and have a long history and their route is known as one of the busiest roads in Fars province.

3. Materials and Methods

For this purpose, soil samples were collected from distance of 2.15 m from two depths of 0-15 cm in a randomized complete block design. Total and absorbable amounts of heavy metals were measured and read with atomic absorption spectrophotometer.

Contamination factor (CF) was used to determine soil pollution to heavy elements. Based on this factor, the amount of elements can be measured in relation to its normal value and determine the degree of soil pollution. The contamination factor was calculated according to the following equation for all elements of the study (Hakanson, 1980).

$$CF_{metal}=C_{metal} / C_{background} \tag{1}$$

where CFmetal is the ratio of the concentration of each metal (Cmetal) to the concentration of the natural background of that metal (Cbackground).

In order to assess the state of soil contamination with heavy metals, the PLI index for the 5 metals under study was calculated. The index, the number of times the concentration of heavy metals in soils and sediments has increased due to pollution and shows a summary of the toxicity of metals (Chan, ., Ng, , Davis, , Yim & Yeung. 2001). The PLI, which is used to study the environmental situation, is defined as the nth root of the multiple concentration of the various metals studied (Angulo, 1996):

$$PLI=\sqrt[n]{\prod_{k=1} CF_{metal}} \tag{2}$$

where CFmetal represents the contamination factor of each metal and n is the number of heavy metals studied.

The RI index has been used by various researchers such as Wang, Z., Wang, Y., Chen, L., Yan, C., Yan, Y., & Chi, Q.(2015). based on the toxicity of metals. According to Hakanson (1986), the toxicity factor for Cd, Zn, Pb, Cr and Zn metals is 30, 5, 5, 2 and 1, respectively. In this study, the ecological risk potential was calculated based on Eq. 3 and 4.

$$E_r^i=\frac{C^i}{C_o^i} \times T_r^i \tag{3}$$

$$RI=\sum_{i=1}^{5} E_r^i \tag{4}$$

Where E_r^i is the potential ecological risk index, C^i and C_o^i, are the measured value and the normal background values respectively and T_r^i is the toxicity response factor of the metal.

4. Results and Discussion

The results showed that the mean concentrations of Ni, copper, Zn, cadmium, and Pb were 1.20, 2.86, 9.81, 10.08, and 84.17, respectively, which was higher than the local background to Pb, and Cd. The highest amount of heavy metals for the nearest road distance is 5 meters and it is 38.86 mg / kg which decreases with increasing distance from the road. The Igeo index calculated indicates no serious contamination of the area with copper, Zn and Ni metals and only Cd and Pb in the contaminated grade to moderate contamination, and high contamination to highly contaminated were affected. In fact, the results of the Igeo index show that these elements are naturally present in the soil, but anthropogenic activity has increased the concentration of these metals in the soil. Results of CF index showed that Ni, Cuand Zn values were less than 1 and were in low pollution class. Whereas, Pb with values range from 6-6 in high pollution class and Pb is with values greater than 6 in high pollution class. PLI index was used to evaluate and determine the contaminated stations. PLI indicator's results for the most polluted stations showed that stations 14 and 23 were classified as highly polluted and the rest of the stations were classified as non-polluting. According to RI results, stations 13, 15, 14, 22, 18, 38, 40, 35, 20, 41, 29, 30, 43, 16, 4, 48, 11, 12, 36, 39, 21, 8 have very high risk and other stations have medium risk. Kriging distribution map of RI index of pollution load index showed that the highest RI index is near the gas pump and near urban areas. Furthermore, the results of Kriging interpolating maps showed that Zn, Ni and Pb are found in the southern region (near Darab city), Cd is found in the north (near Fasa city) and Cuin is found in the northern, central and southern parts.

5. Conclusion

The results of this study showed that the mean concentrations of Pb, Ni, Zn, Cu and Cd in the roadside margins were higher. Statistically, there was a significant difference between the mean concentrations of Pb, Ni, Zn, Cu and Cd within 5 m of the roads and the values (out-of-town locations and other pollutant sources) and in most observations of concentrations of Pb, Ni , Zn, Cuand Cd are higher than background values. This difference is related to the impact of traffic and transportation factors on the contamination of the roadside. Therefore, caution should be exercised in the application of these soils to create green space and even plant crops. The results also showed that Pb and Cd concentrations in areas close to gas pumps and urban areas were higher than other areas, indicating the impact of human activities.

Keywords: Pollutants, heavy metals, Igeo index, CF index, PLI index, RI index, kriging method, road distance.

References :

Abanuz, Y. (2011). Heavy metal contamination of surface soil around Gebze industrial area, Turkey. *Microchemical Journal, 99*, 82-92.

Aguilar Pesantes, A., Peña Carpio, E., Vitvar, T., María Mahamud López, M., & Menéndez-Aguado, J.M. (2019). A multi-index analysis approach to heavy metal pollution assessment in river sediments in the Ponce Enríquez area. *Ecuador Water, 11*(3), 590-598.

Al-Chalabi, A.S., & Hawker, D. (2000). Distribution of vehicular Pb in roadside soils of major roads of Brisbane, Australia. *Water, Water Air Soil Poll, 118*, 299–310.

Angulo, E. (1996). The Tomlinson pollution load index applied to heavy metal, 'Mussel-Watch'data: A useful index to assess coastal pollution. *Science of the Total Environment,* 187(1), 19-56.

Bakirdere, S., & Yaman, M. (2008). Determination of Pb, Cd and Cu in roadside soil plants in Elazig, Turkey. *Environmental monitoring and assessment*, *136*, 401-410.

Carlon, C., D'Alessandro, M., & Swartjes, F. (2007). Derivation methods of soil screening values in Europe. A review and evaluation of national procedures towards harmonization. *European Commission, Joint Research Centre, Ispra, EUR, 306*.

Chan, L.S., Ng, S.L., Davis, A.M., Yim, W.W., & Yeung, C.H. (2001). Magnetic properties and heavy-metal contents of contaminated seabed sediments of Penny's Bay, Hong Kong. *Marine Pollut Bull,* 42(7), 569-83.

Chaturvedi, A., Bhattacharjee, S., Mondal, G. C., Kumar, V., Singh, P. K., & Singh, A. K. (2019). Exploring new correlation between hazard index and heavy metal pollution index in groundwater. *Ecological Indicators, 97,* 239-246.

Chen, J., Wei, F., Zheng, C., Wu, Y., & Adriano, D.C. (1991). Background concentrations of elements in soils of China. *Water Air Soil Poll*, *57*(1), 699-712.

Dash, S., Swapna Borah, S., & Kalamdhad, A. (2019). A modified indexing approach for assessment of heavy metal contamination in Deepor Beel, India. *Ecological Indicators*, *106*, 105-114.

Dolezalova, W. H., Pavlovsky, J., & Chovanec, P. (2014). Heavy metal contamination on urban soil in Ostrva, Czech Republic: Assessment of metal pollution and using principal component analysis. *International Journal of Environmental Research*, *9*(2), 683-96.

Elik, A. (2003). Heavy metal accumulation in street dust samples in Sivas. *Communications in Soil Science and Plant Analysis, 34,* 145–156.

Fakayode, S.O., & Olu-Owolabi, B.I. (2003). Heavy metal contamination of roadside topsoil in Osogbo, Nigeria: its relationship to traffic density and proximity to highways. *Environmental Geology, 44*(2), 150-7.

Feng, Y., Bao, Q., Yunpeng, C., Lizi, Z., & Xiao, X. (2019). Stochastic potential ecological risk model for heavy metal contamination in sediment. *Ecological Indicators*, *102,* 246-251.

Hakanson, L. (1980). An ecological risk index for aquatic pollution control. A sedimentological approach. *Water Research*, *14*(8), 975-1001.

Harrison, R.M., & Laxen, D.P.H. (1977). A comparative study of methods for the analysis of total Pb in soil. *Water Air Soil Poll*, *8*, 387-392.

Harrison, R.M., Laxen, D.P., & Wilson, S.J. (1981). Chemical associations of lead, cadmium, copper, and zinc in street dusts and roadside soils. *Environmental Science & Technology, 15*(11), 1378-1383.

Hegazi, A.A., & El-Kady, A. (2010). Effect of road dust on vegetative characters and leaves heavy metal contents of Zizyphus Spina-christi (L.). willd, Syzygiumcuimini (L.) skeels and Olea europea L. seedlings. *Journal of Horticulture Science and Ornamental Plants*, *2*, 98-107.

Islam, M.S., Ahmed, M.K., Raknuzzaman, M., Habibullah-Al-Mamun, & M., Islam, M.K. (2015). Heavy metal pollution in surface water and sediment: a preliminary assessment of an urban river in a developing country. *Ecological indicators*, 48, 282-291.

Jia, L., Wang, W., Li, Y., & Yang, L. (2010). Heavy metals in soil and crops of an intensively farmed area: A case study in Yucheng City, Shandong Province, China. *International Journal of Environmental Research and Public Health , 7,* 395-412.

Jinfei, F., Jian, Z., Xinmin, B., & Weijian, Z. (2012). Spatial distribution and controlling factors of heavy metals contents in paddy soil and crop grains of rice–wheat cropping system along highway in East China. *Environmental geochemistry and health , 34,* 605- 614.

Kabata-Pendias, A.P., & Pendias, H.H. (2001) Trace Elements in Soils and Plants. *CRC press*.

Khalifa, M., & Gad, A. (2018). Assessment of heavy metals contamination in agricultural soil of southwestern Nile Delta, Egypt. *Soil Sediment Contam, 27*(7), 619-642.

Li, X., Poon, C.S., & Liu, P.S. (2001). Heavy metal contamination of urban soils and street dusts in Hong Kong. *Applied geochemistry, 16,* 1361–1368.

Liu, M., Yang, Y., Yun, X., Zhang, M., Li, Q.X., & Wang, J. (2014). Distribution and ecological assessment of heavy metals in surface sediments of the East Lake, China. *Ecotoxicology, 23*(1), 92-101.

Masoudi, S.N., Ghajar Sepanlo, M., & Bahmanyar, M.A. (2012). Distribution of Pb, Cd, Cu and zinc in roadside soil of Sari-GHaemshahr, rood, Iran. *African Journal of Agricultural Research, 7,* 198-204.

Naser, H.M., Sultana, S., Gomes, R., & Noor, S.H. (2012). Heavy metal pollution and vegetable grown near roadside at Gazipur. Agricultural Research 37: 9-17. Page AL, Miller RH and Keeney DR, 1982. Methods of soil analysis The chemistry of submerged soils. *Adv Agron, 24,* 26-92.

Ndiokwere, C. L. (1984). A study of heavy metal pollution from motor vehicle emissions and its effect on roadside soil, vegetation and crops in Nigeria. *Environmental Pollution (Series B), 7,* 35-42.

Pagotto, C., Remy, N., Legret, M., & LeCloirec, P. (2001). Heavy metal pollution of road dust and roadside soil near a major rural highway. *Environ Technol, 22,* 307-319.

Pendias, A.K., & Pendias, H. (1992). *Trace Elements in Soils and Plants.* Boca Ratton Arbor, London.

Princewell-Ogbonna, L., & Ogbonna, C. (2011). Heavy metal content in soil and medicinal plants in high traffic urban area. *Pakistan Journal of Nutrition, 10,* 618-624.

Qing, X., Yutong, Z., & Shenggao, L. (2015). Assessment of heavy metal pollution and human health risk in urban soils of steel industrial city (Anshan), Liaoning, Northeast China. *Ecotoxicology and environmental safety, 120,* 377-85.

Rahman, S.H., Khanam, D., Adyel, T.M., Islam, M.S., Ahsan, M.A., & Akbor, M.A. (2012). Assessment of heavy metal contamination of agricultural soil around Dhaka Export Processing Zone (DEPZ), Bangladesh: implication of seasonal variation and indices. *Applied Science, 2*(3), 584-601.

Robinson, T.P., & Metternicht, G. (2006). Testing the performance of spatial interpolation techniques for mapping soil properties. *Computers and electronics in agriculture, 50*(2), 97-108.

Safari Sinegani, A.A. (2007). Temporal and spatial variability of Pb levels in Salsola kali near Razan-Hamadan highway. *JASEM, 11,* 143-146.

Sarkar, B. (2002). *Heavy metals in environment.* New York: Marcel Dekker.

Sheng-Gao, L.U., Shi-Qiang, B.A., & Li-Xia, F.U. (2008). Magnetic properties as indicators of Cu and Zn contamination in soils. *Pedosphere,* 18(4), 479-85.

Shi, J., Wang, H., Xu, J., Wu, J., Liu, X., Zhu, H., & Yu, C. (2007). Spatial distribution of heavy metals in soils: a case study of Changxing, China. *Environmental Geology, 52*(1), 1-0.

Sobotra, K., & Tanda, F. (2006). Evaluation of Pb and Cd concentrations in soils and bedrocks. *Environmental Pollutant, 12,* 457-460.

Van Bohemen, H.D., Janssen, V.D., & Laak, W.H. (2003). The influence of road infrastructure and traffic on soil, air and water quality. *Environmental Management, 31,* 50-68.

Wang, Z., Wang, Y., Chen, L., Yan, C., Yan, Y., & Chi, Q. (2015). Assessment of metal contamination in coastal sediments of the Maluan Bay (China) using geochemical indices and multivariate statistical approaches. *Marine Pollution Bulletin*, 99(1-2), 43-53.

Wojciechowska, E., Nawrot, N., Walkusz-Miotk, J., Matej-Łukowicz, K., & Pazdro, K. (2019). Heavy metals in sediments of urban streams: Contamination and health risk assessment of influencing factors. *Sustainability, 11*(3), 563-575.