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Investigation of major heavy metal concentration in urban runoff (case study: North and east catchment of Tehran city)

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ABSTRACT: Urban runoff, as one of the most important emission sources of heavy metal to the environment, has potential environmental and health risks. This study aimed to evaluate the content of ten heavy metals in the runoff of the Sorkheh Hesar catchment, Tehran. For this purpose, Runoff samples were taken from the outlet of Sorkheh Hesar catchment during three flood events in 2018-19 and the total concentration of heavy metals was determined by ICP-MS. Fe, Mn, Zn, Pb, Cu, Cr, Ni, As, Mo and Cd had the highest abundance in all samples, respectively. The results of Spearman's rank correlation coefficient showed a strong correlation (0.71-0.98) between most metals, especially Fe, Mn, Zn, Pb, Ni, Cd and Cu, which indicating the same input sources and similar geochemical behavior. Also, the mean values of Contamination Index, Heavy Metal Evaluation Index and Heavy Metal Pollution Index were 24.7, 30.1 and 130.2, respectively, which indicated most of the samples were in contaminated and high contaminated levels due to high concentrations of three elements including Fe, Mn and Pb in compare to the standard permissible values.

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1. INTRODUCTION

Surface water is considered as one of the most important water sources for various uses, including agriculture, industry, green space and drinking water. Therefore, improving the knowledge about the quality of water resources, especially surface water, is essential for the effective and sustainable management of these resources [1].

During rainwater events, rain washes impervious urban surfaces, after which, a wide range of pollutants carried to receiving environments via storm-water runoff [2]. Therefore, these waters in terms of quantity and quality are considered as one of the major problems in urban environments. These streams contain a wide range of pollutants, including sediments, nutrients (phosphorus and nitrogen), chloride, heavy metals, hydrocarbons, microbial contaminants, organic compounds, etc. Due to the variety and high volume of human activities [3]. Among the various pollutants, heavy metals are important because of their properties such as stability, toxicity, high carcinogenicity and mutation potential, and also bioaccumulation through the food chain [4]. These elements are typically emitted into the environment through natural processes such as chemical weathering of minerals and soil leaching forest fires and volcanic eruptions. The anthropogenic sources are mainly associated with industrial and domestic effluents, urban storm, water runoff, landfill leachate, mining of coal and ore, atmospheric sources and inputs in rural areas [5].

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Measurement of heavy metals in urban runoff as one of the main emission and transmission sources leads to a better understanding of the concentration and behavior of these pollutants. Also, it is a useful tool for evaluating the health of these waters and receiving ecosystems as well as pollution management and control. Some indices**,** including Heavy metals pollution index (HPI), Heavy metal evaluation index (HEI), and Degree of contamination (Cd)**,** has been developed and used to assess the quality of water bodies in terms of the presence of heavy metals and it can be useful for evaluating the quality of urban runoff and its hazard level. The present study aimed to evaluate the runoff quality of the Sorkheh - Hesar catchment with respect to heavy metals concentrations by using conventional indices during three flood events.

2. MATERIAL AND METHODS

The sample collection, storage, preparation, and measurement of heavy metals concentration were performed in accordance with the EPA 200.8 method[6]. The sampling of 3 flood events (30 samples) with a dry period of more than ten days was performed from the outlet of Sorkheh - Hesar catchment in Southeast of Tehran during years 2018 and 2019.

The samples were taken with time intervals during flood events in order to cover the hydrographic variations (base flow to the first flush). The runoff samples were collected from 20 cm of the flow surface using a 5-liter bucket and transferred to 500 ml acid rinsed clean polypropylene bottles and stored in an icebox, then transferred to the laboratory as soon as possible. The samples were acidified with concentrated nitric acid to a pH below 2.0 to prevent metal precipitation and stored in the refrigerator at a temperature below 4 °C. The preparation and analysis of elements were performed less than seven days after sampling. 100 ml aliquot from a well-mixed sample transferred to a 250 ml Griffin beaker. The digestion process was performed using with 3ml the mixture of 65% HNO_3 and 37% HCl (2:1) at temperatures below 90 ◦C for 150 minutes until the sample volume was reduced to 20 ml. the sample solution was transferred to a 50ml falcon tube and made to volume with reagent water, then allowed any undissolved material to settle by centrifuging. Heavy metal concentrations (Pb, As, Cd, Cr, Cu, Fe, Mn, Mo. Ni and Zn) were determined by Inductively Coupled Plasma Mass Spectroscopy.

3. RESULT AND DISCUSSION

The results showed that the concentration of elements increases gradually with the beginning of precipitation and reaches a maximum in the first flush phenomenon, due to the washing effect of surfaces, and then decreases.

Iron with a concentration range of 9.05 – 103.9 mgl^{-1} with an average 39.67 mgl^{-1} and cadmium in the range of 0.25 - 2.95μgl^{-1} with an average of 1.23 μgl^{-1}, had the highest and lowest concentration among the studied elements, respectively. So that more than 90% of the average of the total concentration of the metals were related to Fe and the contribution of Mn and Zn were more than 3.8% and 1.4%, respectively. The share of other elements was less than 1%. The order of dominance in term of concentration of heavy metals in the analyzed samples was Fe >Mn >Zn >Pb >Cu >Ni >As >Mo >Cd. High concentrations of Fe are mostly due to the illegal discharge of municipal, workshop and industrial wastewaters as well as erosion of geological formations [7].

Also, tire abrasion, municipal sewage or galvanized coatings are the most important possible sources of Zn and Mn[8]. Moreover, traffic, car braking system, corrosion and erosion of building materials and pavements are the most important potential sources of Pb, Cu, and Ni in the runoff of the catchment[9]. Comparison of the mean concentration of elements with the allowable limits based on Department of Environment standards indicated that the concentration of Fe was 3-34 times the allowable limits for irrigation and discharge to surface waters in all samples. The concentrations of Mn and Mo were higher in more than 80% and 20% of the samples, respectively, and the rest of the elements were lower than the allowable limits. The high correlation between most elements, especially Fe and Mn, Pb and Cu and Zn, as well as Ni and Fe and Mn, indicates similar emission sources and behavior and the predominance of Anthropogenic sources compared to natural emission sources[10]. The Cd, HEI and HPI indices were evaluated to assess the runoff pollution of the catchment. The range and mean values of Cd in all samples were 5.5 – 68.2 and 24.7, which indicates that all the samples are highly polluted. The HEI index for this study gives a mean of 30.1 with minimum and maximum values of 9.6 and 74.4, respectively, which 97% of samples are moderately and highly contaminated. Also, the HPI index had a mean of 130.2 with a range of 83.2 – 192.7, according to which 87% of the samples (26 samples) were in the polluted level.

4. CONCLUSION

The runoff of Sorkheh - Hesar catchment of Tehran city, was evaluated for its Heavy metal concentration and pollution statue. The study shows that the runoff of the catchment exhibits a high concentration of heavy metals like Fe, Mn, Pb, Zn, Cu, Cr and Ni, which indicates a high extent and variety of emission sources. Generally, the highest and lowest concentrations were observed occurrence of the first flush and after passing that. There was a strong correlation between elements such as Pb, Fe, Cu, Mn, Ni, and Zn, which indicating similar geochemical behavior and emission sources.

Traffic density, pavements and construction surfaces, as well as illegal discharges of municipal and industrial wastewater into runoff networks, are among the most important emissions sources of heavy metals. The values of the three indices in the samples are often higher than the critical values. Therefore, due to the use of runoff in irrigation of crop lands and its discharge to Band e- Alikhan wetland as a sensitive ecosystem, the high concentrations of some elements, in particular Fe, Mn, Pb, Cr and Ni, in these waters can cause serious impacts on surface water and groundwater, arable soils, and agricultural products in the southern regions of Tehran. Therefore, a major bulk of the pollution load can be reduced by using methods to prevent illegal discharge of municipal, industrial and workshop wastewater into the main canal and branches of the runoff network. Also, the major amount of heavy metals are mainly transported linked to suspended particles and sediments, so by designing and using sediment settling ponds or primary treatment facilities at the outlet of the catchment, it is possible to reduce the pollution load of heavy metals in the runoff.

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