Journal of Environmental Studies
Vol. 46, No. 3, Autumn 2020

Journal Homepage: www.Jes.ut.ac.ir
Print ISSN: 1025-8620 Online ISSN 2345-6922

Cancer and Non- Cancer Risk Assessment of Heavy Metals in Ground Water Resources of Varamin Plain

Document Type
Research Paper

Received
June 22, 2020

Accepted
September 26, 2020

Mahnaz Movafaghi Ardestani, Alireza Pardakhti*

Department of Environmental Engineering, School of Environment, College of Engineering, University of Tehran, Tehran, Iran

DOI: 10.22059/JES.2021.317736.1008123

Abstract
Heavy metals are one of the most harmful pollutants in water sources due to their chemical stability and accumulation in tissues. In this study cancer and non-cancer risk assessment of heavy metals in groundwater resources of Varamin plain has been performed for both age groups of children and adults via oral and dermal exposure. The results of non-cancer risk assessment of cadmium, lead, chromium, manganese, zinc, copper and iron showed that cadmium has the highest hazard index (HI) among other heavy metals, which was 0.428 for adults and 1.02 for children. The hazard index of Cadmium for children was higher than the threshold limit that causes non-carcinogenic effects. Also, the hazard index for all heavy metals (HItotal) was found 0.583 and 1.4 for adults and children respectively, which indicated that the hazard index for the age group of children was higher than the threshold limit. The cancer risk assessment showed that the excess lifetime cancer risk (ELCR) of chromium via dermal and oral exposure is 1.528×10-5 which is acceptable by USEPA guideline.

Keywords: Risk assessment, Carcinogenic risk, Ground water, Heavy metals

* Corresponding author Email alirezap@ut.ac.ir

Expanded Abstract

Introduction

The development of countries and the accelerated industrialization has many advantages however they have many problems including the discharge of pollutants into water bodies. therefore the study of quantity and quality of water resources especially groundwater resources which are the main source of drinking water supply worldwide can help us to solve water resources problem.

Problems of water resources pollution in Iran like other developing countries due to growth of population and the accelerated industrialization are increasing. Among water source pollutants, heavy metals cause serious environmental problems. Heavy metals are important because of their properties such as high toxicity, carcinogenicity, non-degradability and mutagenicity. The density of heavy metals is 5 times higher than water. They accumulate in living tissues and eventually enter the human food chain. Due to the bioaccumulation of heavy metals, their release into the environment, even in low concentrations, is a serious threat to plants, animals and humans.

Heavy metals enter the human body through different ways, including food chain, water, skin contact, and inhalation of smoke and particles. Neurological disorders, types of cancer, respiratory disorders, cardiovascular disorders, damage to the liver, kidneys and brain, Hormone imbalance, abortion, arthritis, osteoporosis and death are the effects of entering heavy metal to the human body.

Therefore, due to the toxic effects of heavy metals on the human body, risk assessment of exposure to these compounds is important. Health risk assessment is an important tool for assessing potential adverse health effects of being exposed to contaminated water. Health risk assessment consists of 4 basic steps 1) hazard identification 2) dose response assessment 3) exposure assessment 4) risk characterization

The quality of surface and groundwater resources in Varamin plain is threatened due to the reduction of high quality surface water resources such as Jajrud River in the Varamin plain, using the effluent of the wastewater treatment plant in the south of Tehran to irrigate agricultural lands and population growth as a result of increasing urbanization as well as the development of agriculture and industry. In this study, cancer and non-cancer risk assessment of heavy metals, which had been measured in groundwater resources of Varamin plain before, has been performed for both age groups of children and adults.

Materials and methods

The concentration of heavy metals in groundwater in Varamin plain has been measured for two wet and dry seasons by Nejati Jahromi et al. Here, carcinogenic and non-carcinogenic human health risk assessment of heavy metals in groundwater for both age groups of children and adults were investigated.

Equation (1) was used for non-cancer risk analysis via oral and dermal exposure. Total non-cancerous risk was calculated by summing the non-cancer risk of oral and dermal exposure. Reference dose (RfD) value of cadmium (Cd), lead (Pb), chromium (Cr), manganese (Mn), zinc (Zn), iron (Fe) and copper (Cu) were taken 0.0005,0.0035, 0.003, 0.14, 0.3, 0.7 and 0.04 respectively as per EPA guideline. For dermal risk analysis, RfD_{dermal} were calculated by IRIS formula, where ABS_{GI} for cadmium (Cd), lead (Pb), chromium (Cr), manganese (Mn), Zinc (Zn), iron (Fe) and copper (Cu) were taken 0.05, 0.15, 0.025, 0.04, 0.2, 0.2, and 0.57 respectively as per EPA guideline

$$HQ = \frac{CDI}{RFD} \qquad (1)$$

Cancer and non-cancer risk were calculated by evaluating chronic daily intake (CDI) in mg/kg/days according to equation (2) and (3), Where C is the concentration of heavy metal in mg/L, IR is the daily ingestion rate in L/d,EF is exposure frequency in day/years, ED is exposure duration in year, BW is the body weight in kg, SA is
exposed skin area in cm^2, K_p is dermal permeability coefficient in cm/h, ET is exposure time in hour and AT is the average time in days.

$$CDI_{oral}(mg/kg.d) = \frac{C \times IR \times EF \times ED}{BW \times AT} \quad (2)$$

$$CDI_{dermal}(mg/kg.d) = \frac{C \times SA \times K_p \times ET \times EF \times ED \times \frac{1L}{1000cm^3}}{BW \times AT} \quad (3)$$

To calculate cancer risk via oral and dermal exposure, chronic daily intake (CDI) in mg/kg/days was multiplied by the carcinogenic slope factor(CSF) of hexavalent chromium, where CSF_{oral} value of hexavalent chromium was taken 0.19 as per EPA guideline. For dermal risk analysis, CSF_{dermal} were calculated by IRIS formula. Moreover; cancer cases was calculated by multiplying the risk in the target population.

Discussion of Results

Comparison of the concentrations of heavy metals, which are measured by Nejati Jahromi et al. and the standard values demonstrate that the average concentration of cadmium in both wet (8.02 µg/L) and dry seasons (5.74 µg/L) and the average concentration of lead in wet seasons (12.48 µg/L) are higher than the standard values which are 3µg/L and 10µg/L for cadmium and lead respectively. The results of the non-cancer risk assessment demonstrated that the hazard index (HI) for cadmium due to the lower RFD value of cadmium is higher than other heavy metals (table 1). According to EPA guideline if Hazard Index (HI) is more than 1,it may result in adverse effects on human health. In this investigation, the HQ_{oral} and HQ_{dermal} values of heavy metals for both age groups were less than 1. However the HI of Cadmium for children age group was found 1.024 that is higher than the threshold limit. According to EPA guideline, the cancer risk less than 10^{-6} and the cancer risk between 10^{-6} and 10^{-4} were classified as 'negligible' and 'acceptable' respectively whereas the cancer risk more10^{-4} was classified as 'high'. In this study, the cancer risk through oral and dermal exposure of chromium were estimated to be 1.07×10^{-5} and 4.5×10^{6} respectively that classified as 'acceptable' cancer risk as per EPA. The cancer cases in this area with a population of 990447 people were estimated 15 people.

Table 1 non-cancer risk of heavy metals for children and adults age group

	Heavy metals	Cd	Pb	Cr	Zn	Mn	Fe	Cu	All heavy metals
children	HQ_{oral}	0.904	0.172	0.103	0.0019	0.0033	0.0068	0.0063	1.198
	HQ_{dermal}	0.119	0.03	0.054	3.95×10^{-5}	0.00054	0.00026	7.3×10^{-5}	0.205
	HI	1.024	0.203	0.157	0.002	0.004	0.007	0.006	1.4
adults	HQ_{oral}	0.387	0.0739	0.044	0.00085	0.0014	0.0029	0.0027	0.513
	HQ_{dermal}	0.04	0.01	0.018	1.34×10^{-5}	0.000188	7.67×10^{-5}	2.47×10^{-5}	0.069
	HI	0.428	0.084	0.0625	0.00086	0.00162	0.003	0.0027	0.583

Conclusion

Comparison of the concentration of heavy metals and standard values demonstrated that the concentration of cadmium (Cd) and lead (Pb) is higher than standard values. However the concentrations below the standard cannot guarantee the absence of risk. Therefore, risk assessment is essential. The results revealed that the cancer and non-cancer risks for oral exposure of heavy metals are higher than dermal exposure due to the lower exposure time of dermal. The results of carcinogenic risk assessment of chromium demonstrated that its cancer risk is acceptable as per EPA guideline. The results of the non-cancer risk assessment of heavy metals demonstrated that the total hazard index (HI_{total}) of heavy metals for children age group is higher than threshold limit, therefore it is necessary to use preventive methods to restrict the entry of these heavy metals into the groundwater source or use a suitable treatment method to remove them.