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Purposeful scientific research is a basic pillar for the advancement of Iraq

Health Risk Assessment of Cd, Cr and Mn in Some Vegetables Irrigated by Waste Water

Dalshad Azeez Darwesh
Sciences and Environmental health Dept, College of science, Salahaddin Unversity /Erbil –Iraq
dalshas.darwesh@su.edu.krd

ABSTRACT
This study was carried out to assessment the hazard index and hazard quotient of Cd, Cr and Mn in chard, celery, leek and onion vegetables irrigated by waste water channel and fresh water in Erbil governorate. The results related to vegetable comparisons showed that Cr and Mn contents significantly increased in the magnitude order of chard > leek > onion > celery, while Cd concentrations increased in the order of chard > leek > celery > onion. The concentrations of Cd, Cr and Mn were present to be highest in chard in comparison to other vegetables. However the result show that the highest HI was found in chard (1.101) followed by leek (1.0808) , celery (0.8437) and onion (0.8412).
Keywords: Hazard index and quotient, Waste Water, Vegetables and Heavy metals

1. Introduction
The pollution by heavy metals is primary environmental concern a round world, since heavy metals can harm the ecosystem and causes health problems in humans, therefore a better understanding of heavy metal sources, their accumulation in the soil and the effect of their presence in water and soil on plant systems seem to be particularly important issues of present day research on risk assessments [1, 2] Plant growing in a polluted environment can accumulate the toxic metals at higher concentration causing serious risk to human health when consumed [3]. Damages to vegetation crops caused by trace metals has been recognized because of many botanical and chemical investigation during past 20 years, they mentioned that the food is the major intake source of toxic trace elements by human beings and vegetables are use as staple part of food both in cooked and raw form. Heavy metals were accumulated at high levels in vegetables when irrigated with sewage water, although, some heavy metals are essential for human metabolism, at higher concentration the act as to toxicants, consequently prolonged intake of unsafe concentration of heavy metals lead to disruption of numerous biological and biochemical processes in human bodies [4], thus the determination of metal contents in vegetables is important form the view point of crop yield technology, food nutrition and health impact [5]. Several studies were conducted to investigate the concentration of heavy metals in various vegetables by [6, 7, 8, 9, 10, 1, 12] and [13, 14, 15, 16] around the world and in Iraqi Kurdistan region respectively, all these studies have been indicated that the vegetables particularly the leafy crops grown in heavy metals contaminated soil had a higher concentration of heavy metals than in un contaminated soil. But a few studies carried out around the world and there is no study conduct in Iraqi Kurdistan region about the harmful effect of these elements on human health , in addition many farms around Erbil city apply untreated waste water for irrigation that creates problems for health risk to more than million people in the city, while some farmers used the ground and surface water for irrigation, thus this study was conducted to evaluation the health impact of some trace metals in chard, celery, leek and onion vegetables irrigated by untreated waste water and fresh water around Erbil city vegetables farms.

2. Materials and Methods
2.1 Experimental design
The study was conducted on five locations along the main swage channel three of them were randomly selected near the Tooraq village, while the other two locations were selected which irrigated by the well water near these area the experiment designed in RCBD. The samples of vegetables (chard, celery, leek and onion) were collected from each location by taken the edible parts of plants from various sites at the same location and these samples mixed to form composite sample. The composite samples in laboratory were cleaned by rinse in tape water and then in deionized water for 15 second then the samples oven dry at 70ºC until constant weight, after

drying the samples grinding to pass 1mm sieve, about 1g of plant dried wet digested by using H_2O_2 and H_2SO_4 acid mixture (1:1) after digestion the volume made up to 50ml using deionized water then the heavy metals Cd, Cr and Mn were determined by using atomic absorption flame spectrophotometry.[17 , 18].

2.2 Health risk evaluation

The health risk indices were calculated by using the equations as described by [10] as follow:-

2.2.1 Average Daily Intake (ADI)

The ADI of heavy metal was calculated as a product of average vegetable daily consumption per person, percentage of the dry weight of vegetables, and average heavy metal concentration per dry weight vegetable as shown in the following equation:

$$ADI = \frac{Ci*IR}{BW} \quad .... (1)$$

Where C_i ($mg.kg^{-1}$) is the concentration of heavy metals in vegetables (i = Cd, Cr and Mn, IR (g /day / person) the average daily consumption of vegetables, and BW (kg) the average body weight. The average daily consumption of vegetables suggested by WHO guidelines in human diet is 300 to 350 g per person. The mean of 325 g/person/day was used in calculating the ADI values in this paper. An average weight of person was considered to be 60 kg. [19].

2.2.2 Hazard Quotient (HQ).

Hazard quotient is a proportion of the probable exposure to an element/chemical and level at which no negative impacts are expected. When the quotient is <1, this means no potential health effects are expected from exposure, but when it is >1, it signifies that there are potential health risks due to exposure. The HQ is calculated as a fraction of the determined dose to the reference dose as shown in the following equation:

$$HQ = \frac{EDI}{RfD} \quad .... \quad (2)$$

Where ADI is the average vegetable intake per day (mg/kg/day) and R_fD is the oral reference dose of the metal (mg/kg/day). R_fD is an approximation of daily tolerable exposure to which a person is expected to have without any significant risk of harmful effects during a lifespan.

2.2.3Hazard Index

An exposure to more than one pollutant results in additive effects. Thus, hazard index (HI) is a vital index that assesses overall likely impacts that can be posed by exposure to more than one contaminant. When the HI is >1, this suggests that there are significant health effects from consuming pollutants contained in a foodstuff. The HI is calculated as an arithmetic sum of the hazard quotients for each pollutant as shown in the following equation:

$$HI = \sum_{i=1}^{3} HQ \quad ....(3)$$

2.3. Statistical analysis

The experimental analysis laid out in RCBD. Data were statistically analyzed using SPSS version 24. All data expressed as a mean value. The difference among the means of vegetables and locations were compared by applying Duncan multiple comparison tests at (5%) level of significance, [20].

3. Results and Discussion

3.1. Heavy Metal Levels in Vegetables.

Heavy metals concentration revealed significant variations in the four studied vegetables and locations (Table 1and 2). The concentration ranged from 0.0.173 to 0.615$mg.kg^{-1}$ for Cd, from 0.034to 1.810 $mg.kg^{-1}$ for Cr, and from 17.807 to 31.897 $mg.kg^{-1}$ for Mn. The ranges of all heavy metals under the study in all vegetables as well as in location in were greater than the WHO recommended levels and Pendas and Mukherjee, 2007 allowable limited range of contaminants in food products. The comparison among vegetables revealed that Cr and Mn concentrations decreased in the order of chard > leek > onion > celery, Cd concentrations decreased in the order of chard > leek > celery > onion. Of all the heavy metals, the Cd,Cr and Mn concentration were found to be highest in *chard* in comparison to other vegetables. The highest heavy metals concentration in vegetables can be associated with the nature of the soil as well as the sources of pollutants that discharged to irrigated waste water there were found to have high metals content (Table 1). The highest concentration of Cd Cr and Mn observed in the vegetables have been also observed in Iraq, India and Bangladesh [21, 22, 23]. The disparities in the heavy metals contents may be related to differences in absorption capacities of the vegetables and their translocation within the plants [24] Although Mn is considered to be essential element for numerous bioactivities in the plant body, its high level in the vegetables can affect consumer health negatively [25, 26]. The higher levels of heavy metals in the vegetables could also be attributed to the location of the farms, which is situated along the waste water channel. Heavy metals in the vegetables could be ascribed to agricultural and industrial products that were added or discharged to the waste waters.

Table 1: Mean values of Cd, Cr and Mn mg.kg^{-1} in different vegetables and mg.l^{-1} irrigated locations.

Heavy metals mg.kg^{-1}	plants				Irrigated Locations				
	Chard	Celery	Leek	Onion	Waste water L_1	Waste water L_2	Waste water L_3	Well water L_4	Well water L_5
Cd	0.445a	0.349b	0.424a	0.347b	0.538a	0.481b	0.457b	0.216d	0.264c
Cr	1.12a	0.700b	1.098a	0.709b	1.380a	1.351a	1.213a	0.384b	0.206b
Mn	25.214a	22.751b	25.187a	23.282b	25.728b	24.888b	28.948a	21.855c	19.124d
HI	**1.1012**	**0.8437**	**1.0808**	**0.8412**	**1.2773**	**1.2181**	**1.2048**	**0.5989**	**0.5343**

The same letter in raw show non-significant differences, while different letter refers to significant differences

Table 2: Mean values of Cd, Cr and Mn mg.kg^{-1} and Hazard index in vegetables irrigated by waste water in different locations

Locations	plants	Heavy metals mg.kg^{-1}			HI Hazard Index
		Cd	Cr	Mn	
Waste water channel L1	**Chard**	0.615	1.810	26.860	1.5055
	Celery	0.455	0.962	24.467	1.0870
	Leek	0.559	1.621	25.887	1.3517
	Onion	0.521	1.129	25.697	1.1653
Waste water channel L2	**Chard**	0.500	1.581	24.933	1.3536
	Celery	0.469	1.185	23.657	1.1144
	Leek	0.518	1.417	27.373	1.3316
	Onion	0.437	1.222	23.587	1.0729
Waste water channel L3	**Chard**	0.555	1.336	31.897	1.3456
	Celery	0.395	0.933	26.803	1.0382
	Leek	0.482	1.570	30.730	1.3925
	Onion	0.396	1.014	26.360	1.0428
Well water L4	**Chard**	0.236	0.551	22.387	0.6791
	Celery	0.192	0.353	20.877	0.5351
	Leek	0.263	0.487	21.197	0.6693
	Onion	0.173	0.145	22.960	0.5122
Well water L5	**Chard**	0.319	0.323	19.993	0.6221
	Celery	0.234	0.070	17.950	0.4436
	Leek	0.296	0.397	20.747	0.6589
	Onion	0.208	0.034	17.807	0.4126
Tukyes 0.05		**0.138**	**0.795**	**3.374**	
Sufficient range mg.kg^{-1}	**Chard**	0.029-0.4	0.45-0.85	0.6-20	Pendias and Mukherjee,2007 [10]
	Celery	0.08-0.2	0.02-0.24	16-24	
	Leek	0.029-0.4	0.45-0.84	0.6-20	
	Onion	0.08-0.2	0.02-0.24	16-24	
General allowable limited rang mg.kg^{-1}		0.01-0.2	0.1-0.5	20-300	

3.2. Hazard quotient

The result in figure1 indicated that the hazard quotient (HQ) values of all heavy metals were <1 in all vegetables crops. When HQ exceeds one, this means there are potential health affected by exposure, while when the quotient is >1, this means no potential health effects are expected from exposure. These low values of HQ of heavy metals may be related to that the uptake and bioaccumulation of heavy metals in vegetables are influenced by many factors such as climate, atmosphere depositions, the concentrations of heavy metals in soil, the nature of soil and the degree of maturity of the plants at harvest, hoverers the air pollution may pose a threat to post-harvest vegetables during transportation and marketing causing elevated levels of heavy metals in vegetables. Elevated levels of heavy metals in vegetables are reported which such as long term uses of treated or untreated wastewater, moreover other anthropogenic sources of heavy metals include the addition of manures, sewage sludge, fertilizers and pesticides which may affect the update of heavy metals by modifying the physicochemical properties of the water such as pH, organic matter, bioavailability of heavy metals in the soil [26, 27].

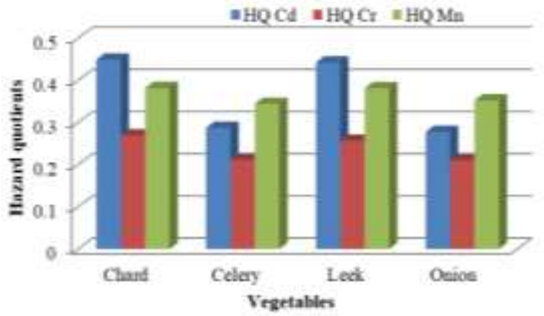

Figure.1 Hazard qoutients of heavy metals in different vegetables

3.3. Hazard Index (HI)

The results in figure 2 show that the highest HI was found in chard (1.101) followed by leek (1.0808) > celery (0.8437) > onion (0.8412). When the HI surpasses unity, this tells us that eating of the food can cause health effects. For this study, consumption of chard and leek by the locals is posing high risks to their health as their HI was greater than one. Figure 3 indicate that in all the studied locations, the higher HI values(1.2773,1.2181 and 1.2048) were observed in vegetables that irrigated by locations (L1, L2 and L2) of the waste water channel respectively compared to the vegetable that irrigated by well water. The findings on the hazard index (HI) revealed that consumption of all vegetables irrigated by waste water channel particularly the chard and leek could pose carcinogenic risks to human health due to high level of Cd and Cr, while consumption of all vegetables under the study irrigated by the well water is reasonably safe.[28]

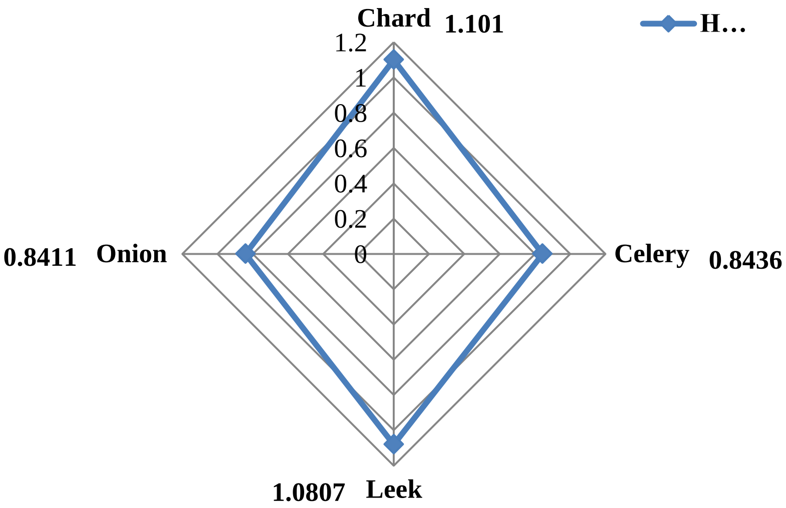

Figure 2. Hazard indices of heavy metals in didderent vegetables

4. Conclusion

According to the findings of the Heavy metal concentration and hazard index (HI) revealed that consumption of all vegetables irrigated by waste water channel particularly the chard and leek could pose carcinogenic risks to human health due to high level of Cd and Cr, while consumption of all vegetables under the study irrigated by the well water is reasonably safe.

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تقييم المخاطر الصحية للكادميوم والكروم والمنغنيز في بعض الخضروات المروية بمياه الصرف ألصحي

دلشاد عزيزدرويش
قسم العلوم وصحة البيئة ، كلية العلوم ، جامعة صلاح الدين / أربيل ، العراق

الملخص

أجريت هذه الدراسة لتقييم معامل الخطورة وحاصل المخاطر لكل من الكادميوم والكروم والمنغنيز في خضروات السلق والكرفس والكراث والبصل المروية بقنوات الصرف الصحي والمياه العذبة في محافظة أربيل. أظهرت النتائج المتعلقة بمقارنة الخضراوات أن محتويات Cr و Mn زادت بشكل ملحوظ في ترتيب تصاعدي السلق> الكراث> البصل> الكرفس، بينما زادت تركيزات الكادميوم بترتيب السلق> الكراث> الكرفس> البصل. كانت تراكيز الكادميوم والكروم والمنغنيز أعلى في السلق مقارنة بالخضروات الأخرى. وأيضا، أظهرت النتائج أن أعلى معامل الخطورة تم العثور عليه في السلق (1.101) يليه الكراث (1.0808) ، والكرفس (0.8437) والبصل (0.8412).