



Heavy metal accumulation in Celery from Sarchnar and Kalar in Kurdistan of Iraq Region.

Khsraw A. Rashid and Zhino. K. Mohammed

Soil and water science Department, Faculty of Agricultural Science, University of Sulaimani, Sulaimani, Kurdistan Region –Iraq, Email: khasraw.rashid@univsul.edu.iq and zhino.mohammed@univsul.edu.iq

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Abstract

Heavy metals pose risk to human health. The present study was carried out to assess levels of different heavy metals like lead, Copper, Chromium, Nickel and Iron, in celery irrigated with water from different sources. The results indicated a substantial build-up of heavy metals in vegetable irrigated with wastewater. The range of various metals in surface water mixed with wastewater-irrigated plants was 0.0005, 0.0003, 0.0086, 0.0006, 0.2106 mg/L for Pb, Cu, Cr, Ni and Fe respectively, in sarchnar location, and lowest value of these metals was determined in well water used for irrigation in kalar location and values are (0.0002, 0.0014, 0.0171, 0.0004 and 0.0020 mg/L) for Pb, Cu, Cr, Ni and Fe respectively. The highest levels of Fe detected in celery value 5.181 and 3.983 mg/kg in Sarchnar and Kalar location, respectively. The present study highlights that both adults and children consuming vegetables grown in wastewater-irrigated soils ingest significant amount of these metals. However, the values of these metals were below the recommended maximum tolerable levels. The regular monitoring of levels of these metals from effluents and sewage, in vegetables and in other food materials is essential to prevent excessive build-up of these metals in the food chain.

Introduction

Heavy metals are high atomic mass ($>5 \text{ g cm}^{-3}$) such as (Hg, Pb, Cd, Ni, Cr...etc.) that can cause the toxicity problem. On the other hand, some of heavy metals have potentially toxic effect on living organisms whilst accumulatively used. [1] Long term waste water irrigation may lead to the accumulation of heavy metals in agricultural soils and plants. Food safety issues and potential health risks make this as one of the most serious environmental concerns [2]. Crops and vegetables grown in soils contaminated with heavy metals have greater accumulation of heavy metals than those grown in uncontaminated soil [3,4] Food and water are the main sources of our essential metals; these are also the media through which we are exposed to various toxic metals. Heavy metals are easily accumulated in the edible parts of leafy vegetables, as compared to grain or fruit crops [5]. Vegetables take up heavy metals and accumulate them in their edible part [6] and inedible parts in quantities high enough to cause clinical problems both to animals and human beings consuming these metal-rich plants [7].

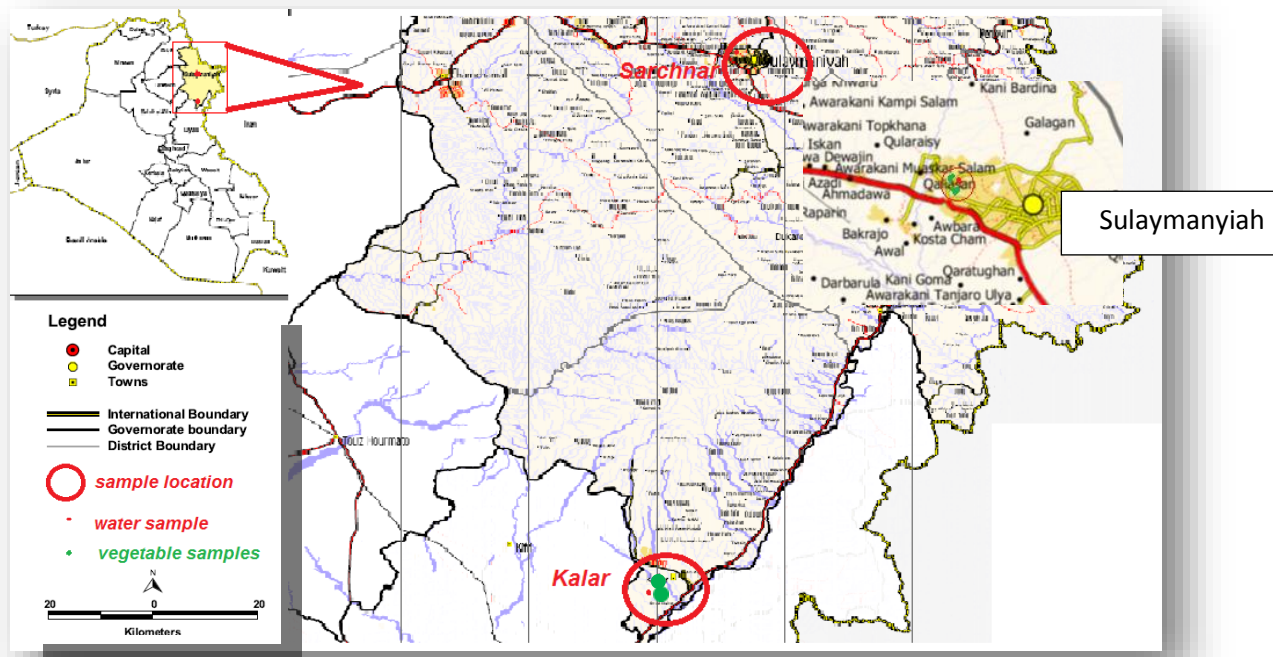
The present study was conducted with an aim to compare the heavy metals (lead, Copper, Chromium, Nickel and Iron) accumulation potential of one of the commonly grown vegetable in Sarchnar and Kalar Kurdistan-Iraq. Irrigation of vegetable with wastewater is a very common practice in Kurdistan. The effect of irrigation with wastewater is also studied in these vegetable (celery) to observe the concentration of accumulated metals to level which human beings are exposed. Furthermore, the daily intake of these metals is calculated for both adults and children, determination of heavy metals concentration in the

irrigated water and Comparing between the concentrations of metals in the vegetable were irrigated by different source of water like: surface water in Sarchnar was joinedwith waste water, well water in Kalar.

Materials and methods

A. Study area and sampling

The water and vegetable (celery) samples were acquired form two different locations, Sarchnar and Kalar.The selected of study area depending on the source of vegetable in Sulaymanyiah market in this time.



Figuer-1: Map of study area.

B. Collection of samples

1. Vegetable sample:

Vegetable (celery) samples were collected from two location farm both Sarchnar and Kalar during 3, November 2013 at the same time. A total of four farms were sampled, two in Sarchnar and two in Kalar. Plants were taken randomly (35 to 65 sample)from each farm and composited to give the homogenize sample [8]. The geographical position for each location are 35.58517°N 45.38014°E for Sarchnar and 34.62102° N 45.32691°E Kalar.

2. Water samples

This research examined the surface water of Sarchnar sub-district which passes by the sewage water in the same location. Surprisingly, the framers have utilized the mixed water, surface water and sewage water, without considering the quality of water that affects celery. Further, this research acquired sample from well water in Kalar district. Moreover, the well water has been used to irrigate frames and produces. Laboratory glass bottles have been used for gathering water samples.

C. Preparation of samples:

1. Water samples

Water samples were brought to the laboratory and filtered with 0.45 µm filters and preserved with 1 ml of 70% HNO₃. The filtered samples were stored in a refrigerator without freezing to minimize volatilization and biodegradation until analysis [9]

2. Vegetable samples

The leaves of leafy vegetable were handpicked, and washed by tap water followed by distilled water, and deionized water to eliminate air born pollutants. After washing the celery samples were sliced thinly before drying. The samples were weighed after washing then dried in an oven at 60°C for 72 hours, and reweighed to determine water content. The dried samples were grind and sieved through a mesh of 1mm diameter. Then homogenized and stored in air tight plastic containers until required for analysis [8].

D. Determination of heavy metals

- **Determination of heavy metals in plant.**

0.5 g powdered from vegetable samples weighed into round tubes to which 50 ml 1:1 H₂O₂:H₂SO₄ were added at different intervals and digested within 3 to 4 hours. All triplicate plant samples were digested at the same time on a Block digester. The acid was evaporated until 1 to 2 ml will remain and cooled at room temperature.

After cooling the digests were diluted by 50ml of distilled water and kept in the refrigeration till analysis. Finally the digested vegetable samples were analyzed for heavy metal determination using Atomic absorption spectrophotometer (AA7000 Shimadzu)[10].

- **Determination of heavy metals in water**

Heavy metals in collected water samples were determined after preparation of samples using Atomic absorption spectrophotometer(AA7000 Shimadzu) for determination.

E.DIM

Daily intake of metals (DIM) calculated using:

$$[\quad DIM = M * K * I / W \quad [11] \quad \text{-----}(1) \quad]$$

Where [M], K, I and W represent the heavy metal concentrations in plants (mg/kg), conversion factor, daily intake of vegetables and average body weight, respectively. The conversion factor used to convert fresh green vegetable weight to dry weight was (0.085) this factor constant for most of vegetables, as described by [12]. The average adult and child body weights were considered to be 55.9 and 32.7 kg, respectively, by means of normal range or healthy weight for adult and child. Despite the fact that average daily vegetable intakes for adults and children were considered to be 0.345 and 0.232 kg/ person/day, respectively, these value of vegetables in actual fact daily intake depending on the weight, as reported by literature [13]and [14].

Results and discussion

1. Physiochemical characteristic and heavy metals concentration in the water samples.

The application of wastewater generally led to change in the physicochemical characteristics of soil and consequently heavy metal uptake by vegetables. Results from (Table:1) shows some physicochemical characteristics of water and heavy metal concentration. The maximum value of pH ,EC, TDS, T, and turbidity were detected in Sarchnar water samples and minimum value for these parameter were detected in kalar water samples. Results show high value of these parameters pH , EC, TDS, T, and turbidity in water sample of Sarchnar may be due to mixed with Sulaimani sewage system (waste water of pipeline), normal range of pH and temperature were determined in Sarchnar and kalar water sample, however the high level of total dissolved salt were determined in Sarchnar location (797 mg/L) which is higher than the normal range (20-500mg/L) according to [15],but the value of total dissolved salt in kalar location was in normal range is 409 mg/L. Turbidity of Sarchnar water samples (61.1 NTU) higher than the normal range (1 NTU -50 NTU) for surface water and irrigation water, according to [16][17],[14] and[18] , this may be due to mixing of sewage water with irrigation water in Sarchnar farm.

The concentration of heavy metals in irrigated water used in Sarchnar and Kalar vegetable farm was showed in (Table: 1) and the concentration of metals (Pb, Ni and Fe) were higher in Sarchnar irrigated water than the Kalar irrigated water and the values (0.5,0.6 and 210µg/mL), respectively and lower value

determined in Kalar irrigated water. The higher value of metals Cu and Cr (1.40 and 17.1µ g/L)respectively, were detected in Kalar irrigated water, and lower value of Cu determined in Sarachnar irrigated water (Table: 1).Concentration of heavy metals in irrigated water were in normal range of quality of water for irrigation according to [19][20].

Table (1): Some physiochemical characteristic and heavy metals concentration of water sample in Sarchnar and Kalar location.

Sample location	pH	EcdS/ m	TDS mg/L	Tc ^o	Turbidity NTU	Heavy metal concentration µg/mL				
						pb	Cu	Cr	Ni	Fe
kalar	6.79	0.309	409	14.5	0.62	0.2	1.4	17.1	0.4	2.0
sarchnar	7.60	0.497	797	15.2	61.1	0.5	0.3	8.6	0.6	210
limit ^[12,13 and14]	6.5- 8.5	0.7- 3.0	20- 500	0-30	1-50					
#Heavy metals ,Normal range for irrigation ^{[16][25]}						5000	200	100	200	5000

Concentration of hevly metals in irrigation water in the orginalrefrences was interpreted by ppm then in the present study changed to ppb to apparent comparison.

2. Heavy metal accumulation in vegetable.

The heavy metals concentrations in edible parts of vegetable in Sarchnar-Sulaymanyiah city and Kalarshown in (Fig: 2) clearly showed that the concentration of heavy metals is higher in vegetables that irrigated with wastewater as a comparison with well water. The highest range of metal concentration in celery were found in Sarchnar location that irrigated by waste water, the greater values of heavy metals uptake is Fe were ranged between (3.983 to 5.181) mg/kg plant in Kalar and Sarchnar location respectively. After Fe the order of metals uptake by celery in Sarchnar location were Pb> Cu >Ni>Cr, and there value are (0.312, 0.140, 0.053 and 0.032 mg/kg Dry weight plant) respectively. Heavy metals uptake by celery in the Kalar location was in order of Fe >Cu>Pb>Ni values (3.983, 0.088, 0.060 and0.022 mg/kg Dry weight plant) respectively, the Cr concentration value is zero in the celery plant fromKalar location the results showing in the (Table: 2) celery leaves were found to accumulate the maximum concentration of iron in the range of (3.983 to 5.181 mg/kg Dry weightplant) these ranges were higher than the permissible limit according to [21].

Results also show the maximum amount of heavy metals accumulation in vegetables that irrigated with waste water, and minimum in well water irrigated farm. The ranges of heavy metals were lower than the permissible limit (Table: 2) except the Iron concentration. This may be due to differences of the heavy metal contents in these vegetable which depend on the physical and chemical nature of soil and absorption capacity of each metals by plant, which is altered by various factors like environmental and human interference, and the nature of the plant [22]

Results are in agreement with previous studies showing elevated levels of heavy metals in edible parts of food crops with continuous wastewater irrigation [23] and [24]. Results from present and previous studies [24], [25], [3] and [4] demonstrate the plants grown on wastewater-irrigated soils are generally contaminated with heavy metals, which poses a major health concern.

Table (2) :Heavy metals determination in celery mg/kg plant dry weight

Location	pb	Cu	Cr	Ni	Fe
sarchnar	0.312	0.140	0.032	0.053	5.181
kalar	0.060	0.088	0.000	0.022	3.983
Permissible limit	2.0**	10**	0.5*,1.3**	10*	2.7***

*[27], **[28], *** [21]

3. Daily intake of metals (DIM)

In order to observe the health risk of any pollutant, it is very important to estimate the level of exposure, by detecting the routes of exposure to the target organisms. There are several possible pathways of exposure to humans but amongst them the food chain is the most important pathway. Daily intake of metals was estimated according to the average vegetable consumption for both adults and children (Tables: 3). The DIM values for heavy metals were low when based on the consumption of vegetables grown in wastewater-irrigated soils.

The highest intakes of Pb, Cu, Cr, Ni and Fe, were from Sarchnar location farm for both adults and children, grown in wastewater-irrigated soils. Daily intake of heavy metals calculation according to equation (1), it is estimated that DIM by plant grown in Sarchnar farm is higher when compared to the Kalar farm, but is nearly free of risks and were far below the tolerable limits, as the dietary intake limits (oral reference dose RfD) [11], [26] of pb, Cu, Cr, Ni and Fe can range from 3.5E-3, 4E-2, 1.5E-0, 2E-2 and 3.0E-0 mg kg⁻¹day⁻¹, respectively [27] [28]. In general, the RfD is an estimate of a daily exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime [27]. The daily heavy metal intake for both adults, and children through the consumption of vegetables in this study was less than RfD limit set by the [27] and [28].

The findings of present study regarding DIM suggest that the consumption of plants grown in sarchnar soils were irrigated by surface water mixed with waste water is nearly free of risks [28], but there are also other sources of metal exposures such as dust inhalation, dermal contact and ingestion (for children) of metal-contaminated soils, which were not included in this study.

Table (3): Daily intake of heavy metals (DIM) by adults and children mg/kg/day according to equation (1) [13] and [14].

		Sarchnar			Kalar				
	Metal mg/kg/day	Adults	Children		Metal mg/kg/day	Adults	Children		
Sarchnar	Pb	0.31	0.00016	0.00019	Kalar	Pb	0.06	0.00003	0.00004
	cu	0.14	0.00007	0.00008		cu	0.09	0.00005	0.00005
	Cr	0.03	0.00002	0.00002		Cr	0.00	0.00000	0.00000
	Ni	0.05	0.00003	0.00003		Ni	0.70	0.00037	0.00042
	Fe	5.18	0.00270	0.00312		Fe	3.98	0.00208	0.00240

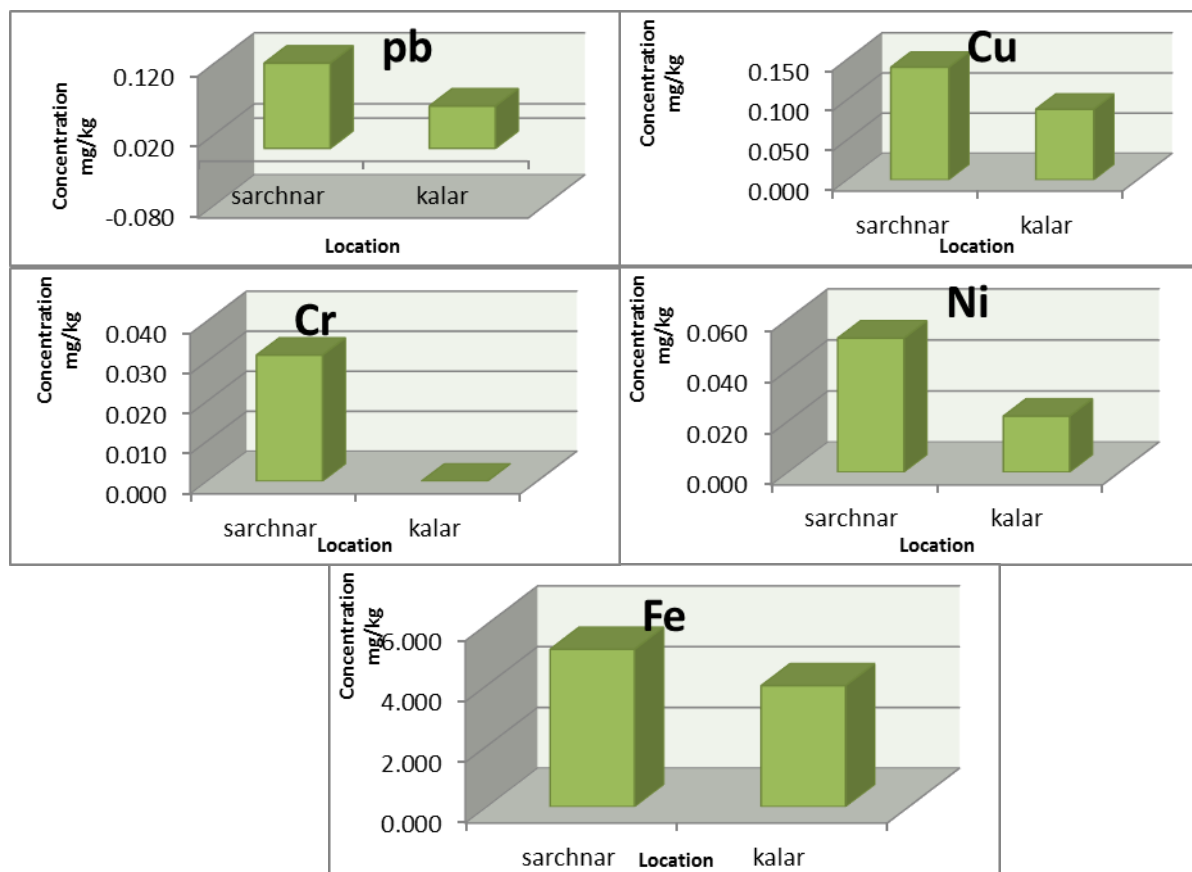


Figure-2: Heavy metals concentration in celery from Sarchnar and Kalar farm were irrigated by different sources of water.

Conclusion:

Heavy metals concentration in irrigated water show in the normal range. Then long-term irrigation of farmlands with wastewater has led to contamination of food crops in the study area. Wastewater-irrigated celery has shown higher accumulation of Pb, Cu, Cr, Ni and Fe, compared to the well water-irrigated celery, indicating the highest metal absorption for celery. The celery vegetable contained heavy metals were lower than the recommended tolerable levels proposed by [27], [28] and [21]. This research study recommends that people living in this area should not consume large quantities of celery, so as to avoid excess accumulation of heavy metals in their bodies. However, the results of present study show that heavy metals contain in vegetable have not affected people’s health yet.

Dietary intake of food results in long-term low level body accumulation of heavy metals and the detrimental impact becomes apparent only after several years of exposure. Thus regular monitoring of these toxic heavy metals from effluents and sewage, in vegetables and in other food materials is essential, to avoid their excessive build-up in the food chain.

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