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RESEARCH PAPER

Erbil residents' daily consumption of heavy metals via sewage and well water-irrigated veggies

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A B S T R A C T:

In Erbil city the farmers used both wastewater and well water for irrigation pupose. An inductively coupled plasma ICP was used to analyze heavy metals., including silver (Ag), aluminum (Al), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), zinc (Zn), chrome (Cr), cadmium (Cd), and arsenic (As), in wastewater, well water, agricultural soils, and vegetables (Chard, Celery, Arugula, Leek and Dill), as well as the health risks they pose in Erbil. Bio-concentration factor (BCF), daily intake (DI), Target Hazard Quotient (THQ), and carcinogenic risks (CR) were calculated to determine health concerns. Overall, metals were found in water, soil, and vegetables. The following is a rundown of the tendencies in these metals' Ni<Ag < Zn < Cr < Mn < Cd < As < Fe < Al < Pb, in the wastewater and well water and As<Ag <Cr< Fe< Cd< Ni< Zn< Mn< Al< Pb in the soil. In the vegetable samples, the mean values mg kg-1 varied from 0.74-13.90, 12.90- 41.70, 2.59- 30.40, 573–1810, 93–292, 2.44 –31.65, 23.10–116, 138–448, 13.70- 40.13 and 1.55 to 14.91, for As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn, Ag, respectively, Cd, Pb, and Mn in chard, Arugula, and celery irrigated with wastewater and well water exceeded WHO/FAW adult safe limits. As, Cd, and Pb THQs were larger than unity in all veggies except sites 2 and 4 for As. Al in sites 1,4,6, and Mn in all sites from Chard plants had THQs > 1. As, Cd, and Cr's CR values above 10^{-4}. These results show that local farmers' habit of irrigating vegetables with untreated wastewater and well water has generated heavy metal deposition in the soils, which is absorbed by vegetables and poses a health concern to the local people.

KEY WORDS: Heavy metal, Vegetables, Wastewater, Well water , Health risk.
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1. INTRODUCTION:

Vegetables are a healthy element of a diet since they provide potassium, fiber, and vitamins. Regular vegetable consumption reduces the risk of cardiovascular disease and several cancers, especially digestive tract tumors (Aysha *et al.*, 2017). However, consuming greens grown in heavy metal-contaminated soil may have deleterious consequences on a person's metabolic and physiological systems (Li *et al.*, 2018). Nitrates and heavy metals may accumulate in agricultural plants from an overabundance of organic and inorganic fertilizers used in the fields, posing a health risk to consumers who consume these products. (Akter et al., 2017, Meng et al., 2018).

Experts from all around the world are very worried about the health effects of the high concentrations of dangerous substances in soil, water, and plants. The possibility of damage from these factors might lead to these dangers. Many cases of heavy metal contamination in products have been documented.. (Mahmood et al., 2020, Sayo et al., 2020). Heavy metals are not biodegradable, therefore they accumulate in the soil and may threaten the local environment (Plants, animals and humans) (Tariq et al., 2019). Some of the most common metals found in wastewater include lead (Pb), arsenic (As), cadmium (Cd), silver (Ag), chromium (Cr), zinc (Zn), nickel (Ni), and copper (Cu). (Ahmed and Ahmaruzzaman, 2016). These metals can persist in wastewater even after treatment, leading to soil contamination and ultimately agricultural and human consumption.(Zinatloo-Ajabshir et al., 2019). Even if wastewater is treated, the soil may

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still be contaminated with these metals, which might eventually be ingested by animals and people..(Rezapour et al., 2019). The heavy metals may cause cancer, genetic mutations, and toxicity. While aluminium itself has not been assigned a carcinogenicity classification, the manufacture of aluminium has been labeled as such by the International Agency for Research on Cancer (IARC). (Loomis et al., 2018). Absorption and ingestion are the most common routes of exposure to toxic metals for humans..(Sayo et al., 2020). The primary route of exposure for humans to some of these metals is via the soil-crop system, which involves the intake of heavy metals (Solidum et al., 2012). According to the kind of heavy metal, they may cause a range of cancers as well as neurotoxicity, shortness of breath, effects that are teratogenic and mutagenic, and other health problems. (Mahdavi et al., 2018). Industrial, municipal, and agricultural runoff containing herbicides and pesticides are examples of wastewater. (Islam et al., 2018). Heavy metals might also be leached into groundwater and ingested by people and animals. (Edokpayi et al., 2017). Rising urbanization and a worldwide shortage of freshwater, especially in poorer countries, are undoubtedly encouraging farmers to use sewage water for cultivation. It's a great help for farmers who lack access to safe water (Rehman et al., 2018, Shekha, 2016). Urbanization generates a lot of sewage. Over 1500 billion cubic meters of wastewater have been used to irrigate 20 million hectares of land..(Qadir et al., 2010). It is estimated to contribute somewhere about 10% of global plant production (tomatoes, lettuce, mangoes, etc.). (Rehman et al., 2018). Several metrics, including the daily intake (DI), health quotient (HQ), transfer factor (TF), and health risk index, are used to evaluate the risks associated with drinking wastewater and well water that health risk index is used (HRI) (Kachenko and Singh, 2006). The objectives of the research are (i) to determine the levels of heavy metals in the soil and certain crops that have been irrigated with water from the main Erbil canal and well water, and (ii) to evaluate the daily consumption and health risks associated with eating such vegetables.

2. Materials and Methods:

2.1.Study area

Erbil, Iraqi Kurdistan's capital, has more than a million people. Three places near Erbil's sewage canal or irrigated with sewage were selected using GPS (Garmin) and three well-irrigated vegetable fields in Erbil Table 1. The study area is southwest of Erbil to Demhat region, from 36.169538 Latitude to 36.100762 Latitude and 43.929734 Longitude to 43.812271 Longitude. Figure and Table 1

Table 1: Samples coordination and types of Irrigated water used for agriculture production.

Site No.	Location	Latitude DD*	Longitude DD*	Z(altitude) m (a.s.I)	Type of Irrigated water
1	Turaq 1	36.169538	43.929734	379	Waste water
2	Turaq 2	36.155158	43.917439	365	Well water
3	Jmka 1	36.126431	43.855755	323	Waste water
4	Jmka 2	36.129563	43.860852	327	Waste water
5	Daleguly khwarey	36.120052	43.855984	325	Well water
6	Dhemat	36.100762	43.812271	307	Well water

GPS*: Global positioning system, DD*: Decimal degrees, m.a.s.l: meter above sea level

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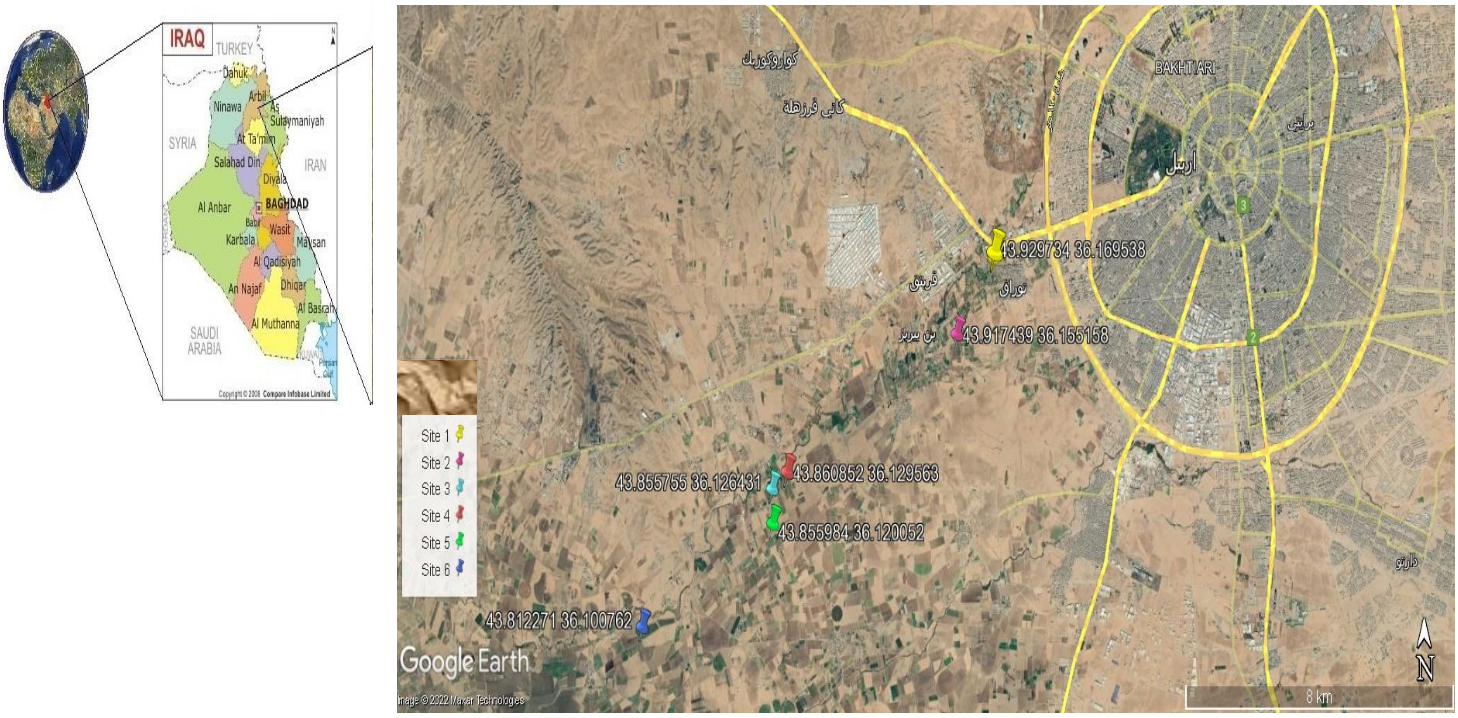

Figure 1: Location Map of the study area showing the sample location.

2.2.Samples collections and preparations

2.2.1.Plant samples:

Stainless steel knife was used to obtain about 1 kg of edible parts of different vegetables [Chard (*Beta vulgaris* var. *cicla),* Celery (*Apium graveolens*), Arugula (*Eruca Sativa),* cress, (*Allium porrum* L.) and leek, (*Antheum graveolens)*] were collected from six vegetable farms (three site irrigated by wastewater and three sites irrigate with well water) over the summer, fall of 2020, and winter, spring of 2021. Each vegetable sample was cleaned with tap water and distilled water to remove debris and dust particles. The edible sections of the samples were air dried for 2 days and oven dried. After drying, materials were ground into a fine powder and kept in plastic bags until wet digestion as reported by (Samsuri et al., 2019). Following the wet digestion method as described by (Naeem et al., 2012) to test vegetable samples for heavy metals. Briefly, 0.5 g of dried vegetable was digested with H_2O_2 and H_2SO_4 till visible vapors were produced. The samples were chilled, filtered on Whatman No. 42 paper, and diluted with distilled water.

2.2.2.Soil sample:

Using a stainless and clean steel trowel, soil samples were collected from the surface to 30 cm surrounding plant roots and sent to a laboratory at Salahaddin University's College of Education. Air-dried, coarsely powdered, then sieved through 2-mm to remove trash, stones, and pebbles. 500 g of soil samples were dried at 105 °C for 2 h to eliminate all moisture before the examination 5 g of dry soil was mixed with 50 mL of pH 7 EDTA and ammonium acetate extraction solution and agitated for 2 hours at 120 rpm. The supernatants were obtained after centrifuging the aliquot for 5 minutes at 5000 rpm (Pansu and Gautheyrou, 2007).

2.2.3. Water sample:

Polythene buckets are used to collect water samples.Sample collection prevents foreign material contamination. All analytical sample containers and glasses were cleaned with distilled water. Water samples were acidified with 1:1HNO3/D.W for heavy metals detection to minimize precipitation and adsorption, then frozen for physicochemical parameter assessment. (Rice et al., 2012), standard method, wastewater and well water are tested for pH, EC, TDS, Cl, Ca^{++}, Hardness, Alkalinity, Turbidity, NO_3^-, $SO_4^{=}$,Mg^{++}, K^+, Na, and PO_4^{-3}. (ICPE SHIMADZU 9820 multi – element standard solution IV) at Bashmakh quality control lab analyzed vegetable, soil, and water samples for As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn and Ag. Four global characteristics were utilized to evaluate wastewater-irrigated crops' health risks.

2.3. Bio-concentration factor (BCF):

The BCF is a parameter that is used to describe how metals move from contaminated soil to certain plants. (Samsuri et al., 2019) and the equation used to arrive to that conclusion is as follows:

$$\mathrm{BCF} = \frac{\mathrm{Cv}}{\mathrm{Cs}}$$

Where, *BCF* is the Bio-concentration factor, *Cv* and *Cs* are the concentrations of heavy metals (m kg^{-1}) in the edible part of vettgetables and soil, respectively.

2.4. Daily intake of heavy metals (DITM):

The DITM (mg kg^{-1} d^{-1}) The following formula was used to determine the exposure risk to heavy metals from eating vegetables.

$$\mathrm{DITM} = \frac{\mathrm{DIV} * \mathrm{C}}{\mathrm{BW}}$$

Where C represents the concentration of metals in the edible part of vegetable in mg kg-1, DIV is a daily intake (daily vegetable consumption rate for adult residents was 33, 15, 13, 5 and 4 g fresh weight basis for Chard, Celery, Arugula, Leek and Dill respectively, questionnaire survey of this study) and BW represents body weight in (kg) which assumed 70 kg for adult (Hawrami et al., 2020).

2.5. Target hazard quotient

Target hazard quotient (THQ) is the ratio of hazardous element exposure to the reference dose, the greatest amount without harmful health consequences. The reference dosage is trace element-specific. THQ defines noncarcinogenic health risk from toxic element exposure. When the THQ value is less than 1, no carcinogenic consequences are anticipated. However, if the THQ is more than 1, then potential negative health consequences exist. When the THQ value is more than 1, this does not always indicate an increased risk of cancer or other serious health problems. U.S. Environmental Protection Agency guidelines were used to calculate the THQ (Panel and Human, 2010).

$$\mathrm{THQ} = \frac{E_{FR} \times E_d \times E_{IR} \times \mathrm{C}}{\mathrm{RfD} \times \mathrm{BWa} \times \mathrm{ATn}} \times 10^{-3}$$

Where E_{FR} is the exposure frequency to the trace element, E_D is the exposure duration (70 yrs), E_{IR} is the food ingestion rate in grams per day for the respective food item, C is the concentration in a wet weight of the trace element in the given food item, RfD is the oral reference dose of the trace element in mg/kg/day The oral reference doses were based on 0.0003, 0.0005, 1.5,1, 0.004, 0.02, 0.033, 0.7, 0.3 and 0.005 mg/kg/day for As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn and Ag respectively,(Islam et al., 2014) BWa is the reference body weight of 70 kg and ATn is the averaged exposure time (365 days*70yrs) and 10^{-3} is the unit conversion factor. Totaling the target hazard quotients of the items evaluated for each food category yields the hazard index (HI). The HI presupposes that a single serving of a certain meal would expose a person to several potentially harmful substances. Consistent eating may have negative health consequences even if the THQs of the food's constituent components are below unity on their own. Non-cancerous health problems may occur if the HI is greater than 1 (Panel and Human, 2010).The equation for HI is:

$$\mathrm{HI} = \sum_{\mathrm{N}=1}^{\mathrm{i}} \mathrm{THQn}$$

2.6. Cancer risk:

The cancer risk (CR) is used to evaluate the possible danger associated with exposure to carcinogenic substances throughout a lifetime. For the estimation of THQ, rather than using an oral reference dosage, an oral slope factor is employed. Along with the dosage of the carcinogen, this component determines the likelihood of an elevated cancer risk throughout the lifespan of the exposed person.The equation for CR is:

$$CR = \frac{E_{FR} \times E_D \times E_{IR} \times C \times CPSa}{BWa \times ATc} \times 10^{-3}$$

Where E_{FR} is the exposure frequency to arsenic, E_D is the exposure duration (70 yrs), F_{IR} is the food ingestion rate in grams per day for the respective food item, C is the concentration in wet weight of the trace element in the given food item, CPSa is the oral cancer slope factor for As,Cd and Cr were 1.5, 0.38 and 0.5 respectively (mg/kg)/day, BWa is the reference body weight of 70 kg, ATc is the averaged exposure time to the carcinogen (365 days*70yrs) and 10^{-3} is the unit conversion factor(Singh et al., 2010).

The amalgamated cancer risk (TCR) associated with all carcinogenic target heavy metals. The ranking criteria of the combined cancer risk (TCR) is the same as *CRi* (Wen et al., 2019). The equation for TCR was calculated using

$$TCR = \sum_{N=1}^{i} CRn$$

2.7. Statistical analysis:

Before statistical analysis, all data were examined for homogeneity, normality, and variances. The data precisions were computed and reported as standard deviations (SD). The data were then submitted to statistical analysis using the past 4.03 software and provided in terms of mean (four replications) and standard deviation..

3.Results and discussion:

3.1. Wastewater and well water characterization

Results of selected physicochemical parameters and concentrations of heavy metals in examined wastewater and groundwater are reported in (Table 2).The maximum values for pH, EC, TDS, Hardness, Ca, Cl, SO_4, PO_4, NO_3, Na and K were 7.92, 1078(µs/cm), 689.92 mg L^{-1}, 470 mgCaCO3/L, 72.14 mg L^{-1},59.56 mg L^{-1},102.76 mg L-1,0.46 mg L^{-1},43.31 mg L^{-1},42.37 mg L^{-1} and 6.16 mg L-^{1} respectively. These values are lower than the Food and Agriculture Organization guideline for irrigation water (Commission, 2001). However, the highest levels of Alkalinity 434 mg $CaCO_{3.}$ $l^{-1}$and Mg^{++} 89.91 mg. l^{-1} were more than those recommended by the FAO. In addition, the highest value of K+, 6.16 mg. l^{-1}, is only greater than the FAO-recommended limit at three waste water sites, whereas it is lower at three well water sites. Changes in temperature, season (summer,winter,utuman and spring), human activities, soil type, and surface conditions often led to differences in wastewater characteristics and nutrient content across places (Edokpayi et al., 2017).The concentrations of As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn, Ag, in the wastewater samples collected on three sited of wastewater and three well water are shown in Table 3. In general, most metals had larger concentrations in wastewater sites, with the exception of Cd and As, which had high concentrations in site 2 (well water). This may be attributed to the fact that waste streams receive huge amounts of agricultural drainage, sewage, and industrial wastewater. (El-Amier et al., 2020, Esposito et al., 2018). Metals may readily bind to clays, organic matter, iron oxides, manganese oxides, and other particles in water, and these pollutants can travel rapidly. (Zhang et al., 2017). Other explanations include hydrogeological and geochemical aspects of the well's area. (Commission, 2001). According to the FAO, Ag, Al, Cr, Fe, Mn, Ni, Pb, and Zn concentrations in all analyzed locations are below the recommended limit for irrigation, however Cd and As concentrations are greater than those reported by FAO.(Commission, 2001)

Table 3: Concentrations of metals in waste water and well water sampled from six locations .

Sites	As (mg/l)	Cd (mg/l)	Cr (mg/l)	Al (mg/l)	Pb (mg/l)	Ni (mg/l)	Mn (mg/l)	Fe (mg/l)	Zn (mg/l)	Ag (mg/l)
S1	0.29	0.27	0.083	1.24	1.22	0.012	0.19	1.09	0.071	0.037
S2	0.43	0.45	0.088	1.16	1.47	0.014	0.09	0.32	0.061	0.033
S3	0.32	0.26	0.071	1.00	1.17	0.012	0.18	0.64	0.015	0.027
S4	0.37	0.29	0.091	0.99	1.49	0.014	0.19	0.78	0.016	0.025
S5	0.21	0.40	0.077	0.77	1.27	0.012	0.07	0.21	0.035	0.029

S6	0.36	0.33	0.074	0.77	1.14	0.011	0.07	0.20	0.033	0.025
Mean	0.33	0.33	0.081	0.99	1.29	0.012	0.13	0.54	0.039	0.029
SE	0.03	0.03	0.003	0.08	0.06	0.001	0.03	0.15	0.010	0.002
CV%	23.13	22.96	9.958	19.75	11.70	10.504	46.92	66.74	60.430	15.835
Permissible limits worldwide										
USEPA and FAO	0.1	0.01	0.1	5	5	0.2	0.2	5	2	0.1

SE:Standard error; CV: Coefficient of variation, Permissible limits for irrigation water are set by the Food and Agriculture Organization and US environmental protection agency (FAO) and (USEPA)

The reason is that oil refineries and iron factories are only a few kilometers away from the study site. This means that there is more and more cadmium in each water sample. Cadmium can get into water systems when chemicals are released from materials that contain it or when leaching to ground water. Farmers use pesticides to protect their crops and get the most from them. Since it was once used in pesticides, arsenic seems to be very common. Runoff from nearby farms can carry arsenic into water systems, making the amount of arsenic in the water go up. (Shaji et al., 2021). The current wastewater and well water is not suitable for vegetable irrigation. Heavy metals in wastewater accumulate in soil and are accessible to plants, according to Chaoua et al. (2019).

3.2. Heavy metals concentration in soil:

The mean concentrations Table 4 displays (mg/kg) of As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn, and Ag on soil irrigated with wastewater. Results were compared to FAO and WHO maximum permitted heavy metal concentrations in agricultural soils.

Table 4: Six soil samples' metal concentrations.

mg/kg										
Sites	As	Cd	Cr	Al	Pb	Ni	Mn	Fe	Zn	Ag
S1	35±0.61	131±2.65	412±3.15	5100±8.45	710±4.58	168±5.04	1260±15.37	1430±10.78	3480±6.54	176±3.04
S2	33±0.58	134±2.25	384±3.95	4940±9.55	664±5.03	117.4±6.65	1480±11.04	1046±9.54	1490±9.62	183±2.89
S3	31±0.76	140±03.60	415±2.05	4660±8.75	722±5.77	210±6.24	3480±10.20	990±8.42	1226±8.84	212±4.80
S4	88±0.66	123±1.75	397±4.26	5600±9.65	740±6.92	183.4±20.5	3420±9.67	982±7.04	1448±7.59	178±2.54
S5	69±0.84	135±1.90	396±5.35	5300±7.96	710±12.50	180±5.50	2520±13.25	882±7.78	1448±5.78	204±2.76
S6	81±0.56	124±3.45	404±3.76	5540±9.44	700±10.59	206±2.08	2760±8.34	1038±8.14	2480±5.51	182±3.23
Mean	56	131	400	5190	708	178	2487	1095	1929	189
FAO& WHO	30	3	100	80000	250	100	2000	50000	300	500

± SD , FAO& WHO(Commission, 2001)

The mean concentrations of As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn and Ag 56, 131, 400, 5190, 708,178, 2487, 1095, 1929, 189 mg/ kg respectively. The trend for heavy metals concentration in the studied soils were in the descending order of Al > Mn > Zn > Fe > Pb> Cr> Ag > Ni > Cd> As. The total quantity of metals ssoils irrigated with wastewater and well water above WHO/ FAO permitted limits, however Al, Fe, and Ag were below these limits. Table 4. Al, Fe, and Ag concentrations were below WHO/FAO allowed levels. Heavy metals concentrations below prescribed limits in soil irrigated with wastewater may be the result of ongoing absorption by plants and leaching into the soil profile. (Chaoua et al., 2019). In general, the majority of metals had higher amounts in the irrigated wastewater. This may be attributed to the fact that waste streams receive huge amounts of agricultural drainage, sewage, and industrial wastewater. (Commission, 2001). Fast diffusion of pollutants and the capacity of metals to bind to clays, organic matter, iron and manganese oxides and other particles in water. (Zhang et al., 2017). Other reasons could be the hydrogeological and geochemical features of the soil in the area that was looked at. (Ememu and Nwankwoala, 2018).These soils may contaminate nearby ecosystems. Study locations are the most polluted, presumably because they're near oil refineries.

3.3. Heavy metals concentration in vegetables:

Waste-water and well-water irrigated chard, celery, arugula, leeks, and dill shows Table 5. Dry plant weights determine metal concentrations. Due to variable accumulating capacities and soil conditions, vegetable metal concentrations differed. The maximum concentration of metals recorded in wastewater and well water irrigated vegetables 13.9, 41.7, 30.4, 1810, 291, 31.65, 116, 448, 40.13 and 14.91 mg/ kg for As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn and Ag, respectively, Heavy metal concentrations are greater in waste water irrigated vegetables than in well water irrigated vegetables. As concentrations in vegetables were between 13.90 -3.50 and 7.88-0.74 for wastewater and well water, respectively (Table 5). The Celery had the maximum As accumulation at site 4 (wastewater), and the content of As in all vegetables at all examined locations was greater than WHO/FAO acceptable limits. Farmers employ pesticides to protect their crops and increase harvests. Arsenic seems to be particularly common since it was formerly employed in insecticides. This indicates that the level of arsenic in each vegetable sample is increasing. Cadmium levels in waste and well-water irrigated crops ranged from 12.90 to 41.70 mg/kg, with the highest concentration reported in chard (Table 5).

Our Cd findings for wastewater and well- irrigated vegetables show higher levels than the safe limit set by WHO/FAO (0.2 mg/ kg), According to Aksoy et al. (2005), its intake proved detrimental to human health. In this research, the high amounts of Cr, Pb, and Ag found in Arugula, Celery, and Chard are greater than the WHO/FAO safe limit for Cr, Pb, and Ag. The rationale is that iron production facilities are within a few kilometers of the research locations. In this plant, discarded automobiles, batteries, and unused heavy machinery are gathered from throughout the nation and turned into aliquid using specialized furnaces. Through the process of dissolving, a portion of the factory's waste is expelled in the form of dust, which is then dispersed through the air and deposited in numerous locations, including adjacent water resources (wastewater and well water) and vegetable fields. This indicates that the levels of Cr, Pb, Ag, and Cd in each vegetable sample are increasing. Our results complement a research that found the greatest Pb levels in waste- and well-irrigated crops. Pb poisoning in children and adults may cause brain and immune system abnormalities, anemia, cardiovascular disease, bone metabolism, renal and reproductive failure (Hasson et al., 2015). Trace elements may enter vegetables in two ways: first, they can be absorbed through contaminated soils; in this research, heavy metals in all chosen vegetables except Ni and Mn, Zn and Fe above WHO/FAO permissible limits. This conclusion is consistent with the findings from the soil studies; second, they may be deposited on the surfaces of vegetables exposed to contaminated environments. (Manzoor et al., 2018). When consumed on a consistent basis, trace elements may lead to a variety of adverse health effects in humans as well as in other species (Kilunga et al., 2017). Long-term exposure to very low concentrations of carcinogenic trace elements has been related to a variety of cancers. (Deng et al., 2019). Arsenic, cadmium, and chromium are all considered "carcinogenic to humans" by the International Agency for Research on Cancer (IARC).(Loomis et al., 2018). The results showed that the Ni, Mn, Fe and Zn were the metals least accumulated by plants, compared to other metals Table 5. Ni, Mn, Fe and Zn concentration did not exceed the limits determined by FAO/WHO,(67,300,450 and 60) This explains that there is no significant risk in terms of the Ni, Mn, Fe and Zn concentrations in studied vegetables. All vegetables showed some degree of variation in Al content, although chard, celery, and arugula all had readings that were greater than the WHO/FAO recommended maximum in more than one location. Vegetables with bigger leaves, including chard, celery, and arugula, have agreater capacity to absorb and collect the water in the soil than other small leave or spiny leaves and then collect the heavy metals. (Zhou et al., 2008)

3.4. Health risk assessments:

Three common metrics, BCF, DI, and HQ and CR, were used to estimate the human health hazards posed by ingesting vegetables irrigated with wastewater and well water. Several studies has revealed that the BCF evaluation is required to evaluate the health concerns connected with wastewater-irrigated plants.; (Sayo et al., 2020, Chaoua et al., 2019, Hawrami et al., 2020, Mahmood et al., 2020, Tariq et al., 2016) Where is BCF ≤ 1, it indicates that the vegetable only has the ability to absorb metals but has not accumulated while BCF >1, it means that the vegetable accumulates metals (Chaoua et al., 2019, Tariq et al., 2016). Table 6 shows the BCF values of heavy metals in vegetables irrigated with wastewater and well water. The BCFs value ranged from 0.01to 0.27, 0.10 to 0.30, 0.001 to 0.203, 0.09 to 0.57,0.13 to 0.44 and 0.01 to 0.17, 0.0068 to 0.0614,0.10 to 0.65, 0.0045 to 0.0279, 0.0003 to 0.495 for As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn and Ag , respectively. Differences in metals BCF values across vegetables were ascribed to metal binding capability on vegetable roots. Toth et al. (2009) reported that the plant species, genotype and bioavailability of metals in soil (Avci and Deveci, 2013, Bose and Bhattacharyya, 2008, Chaoua et al., 2019). Overall, the present investigation found that the BCF values of all metals in various vegetables were less than one. This demonstrated that the veggies absorbed just the metals but did not accumulate the heavy metals. (Satpathy et al., 2014).

Table 6: shows the Bio-concentration values for vegetables irrigated with wastewater.

Sites	Type of vegetables	As	Cd	Cr	Al	Pb	Ni	Mn	Fe	Zn	Ag
S1	Chard	0.02	0.21	0.02	0.34	0.15	0.05	0.04	0.44	0.01	0.02
	Celery	0.01	0.17	0.01	0.11	0.16	0.03	0.03	0.16	0.01	0.08
	Arugula	0.03	0.20	0.03	0.32	0.24	0.06	0.03	0.65	0.00	0.02
	Leek	0.01	0.14	0.01	0.17	0.16	0.01	0.02	0.23	0.01	0.08
	Dill	0.01	0.14	0.01	0.13	0.15	0.05	0.03	0.22	0.01	0.06
S2	Chard	0.02	0.28	0.02	0.26	0.24	0.07	0.05	0.26	0.01	0.47
	Celery	0.17	0.18	0.03	0.25	0.22	0.13	0.05	0.43	0.03	0.07
	Arugula	0.15	0.20	0.08	0.29	0.44	0.16	0.06	0.58	0.02	0.08
	Leek	0.09	0.13	0.02	0.17	0.16	0.12	0.03	0.20	0.02	0.01
	Dill	0.18	0.12	0.02	0.16	0.16	0.11	0.03	0.24	0.02	0.02
S3	Chard	0.27	0.30	0.02	0.14	0.24	0.05	0.03	0.18	0.02	0.08
	Celery	0.22	0.15	0.02	0.14	0.19	0.17	0.01	0.25	0.02	7.09
	Arugula	0.18	0.18	0.03	0.22	0.23	0.13	0.01	0.30	0.03	0.45
	Leek	0.17	0.18	0.03	0.15	0.18	0.05	0.01	0.24	0.02	0.49
	Dill	0.16	0.14	0.06	0.14	0.18	0.05	0.01	0.21	0.01	0.08
S4	Chard	0.11	0.16	0.02	0.32	0.26	0.03	0.02	0.25	0.01	0.01
	Celery	0.16	0.10	0.03	0.57	0.39	0.07	0.01	0.44	0.01	0.0003
	Arugula	0.07	0.18	0.03	0.29	0.19	0.14	0.01	0.50	0.02	0.02
	Leek	0.04	0.11	0.02	0.20	0.13	0.03	0.01	0.23	0.02	0.01
	Dill	0.06	0.15	0.01	0.14	0.14	0.03	0.01	0.18	0.01	0.01
S5	Chard	0.10	0.30	0.03	0.18	0.24	0.06	0.04	0.33	0.01	0.01
	Celery	0.11	0.13	0.03	0.35	0.23	0.05	0.01	0.36	0.02	0.01
	Arugula	0.09	0.16	0.20	0.09	0.20	0.13	0.01	0.19	0.02	0.01
	Leek	0.11	0.15	0.03	0.35	0.20	0.08	0.02	0.35	0.02	0.01
	Dill	0.08	0.14	0.03	0.12	0.15	0.08	0.02	0.26	0.02	0.01

S6	Chard	0.09	0.26	0.00	0.38	0.17	0.01	0.03	0.10	0.01	0.01
	Celery	0.08	0.17	0.02	0.16	0.18	0.05	0.02	0.21	0.01	0.02
	Arugula	0.09	0.20	0.03	0.30	0.20	0.14	0.01	0.30	0.01	0.01
	Leek	0.06	0.12	0.02	0.19	0.14	0.04	0.01	0.18	0.01	0.01
	Dill	0.08	0.17	0.02	0.15	0.15	0.04	0.01	0.13	0.01	0.01

In countries like Iraq, where wastewater and well water are still used for agriculture, food-chain risk evaluation of heavy metals is essential, daily metal intake is shown (Table 7). Humans are exposed to hazardous metals via soil, water, air, and food (Solidum et al., 2012).

Table 7: daily intake of heavy metals via consumption of studied vegetables (mg kg^{-1} d^{-1}).

Daily intake of heavy metal ($DI*10^{-3}$)											
Sites	Type of vegetales	As	Cd	Cr	Al	Pb	Ni	Mn	Fe	Zn	Ag
S1	Chard	0.39	1.42	0.52	92.39	5.75	0.48	2.90	23.61	1.03	0.17
	Celery	0.14	0.41	0.11	13.74	2.71	0.13	0.87	4.70	0.43	0.32
	Arugula	0.15	0.40	0.26	34.95	3.61	0.23	0.84	9.37	0.33	0.08
	Leek	0.04	0.14	0.05	7.34	0.99	0.02	0.24	2.37	0.26	0.12
	Dill	0.03	0.10	0.03	4.41	0.66	0.06	0.26	1.70	0.13	0.07
S2	Chard	0.04	1.97	0.43	67.99	8.43	0.46	3.58	14.60	0.87	0.45
	Celery	0.14	0.56	0.28	29.08	3.52	0.35	1.61	9.78	0.96	0.33
	Arugula	0.10	0.59	0.65	26.58	6.20	0.40	1.93	8.65	0.59	0.32
	Leek	0.02	0.14	0.08	7.04	0.87	0.12	0.37	1.79	0.28	0.02
	Dill	0.04	0.11	0.05	5.17	0.69	0.08	0.26	1.61	0.15	0.02
S3	Chard	0.44	2.20	0.43	35.47	8.80	0.50	6.11	9.49	1.11	0.76
	Celery	0.16	0.49	0.21	15.97	3.21	0.76	1.01	5.87	0.52	0.17
	Arugula	0.12	0.55	0.27	21.67	3.38	0.49	1.05	6.23	0.73	0.08
	Leek	0.04	0.21	0.09	5.95	1.04	0.08	0.38	2.00	0.22	0.02
	Dill	0.03	0.12	0.15	4.08	0.83	0.06	0.22	1.33	0.10	0.01
S4	Chard	0.51	1.04	0.49	95.40	9.86	0.33	3.67	12.81	0.92	0.09
	Celery	0.33	0.31	0.34	28.29	6.74	0.33	0.87	10.31	0.40	0.04
	Arugula	0.14	0.47	0.25	32.96	2.95	0.63	0.82	8.86	0.56	0.07
	Leek	0.03	0.11	0.07	7.18	0.79	0.06	0.20	2.04	0.19	0.02
	Dill	0.03	0.12	0.03	4.82	0.64	0.05	0.22	1.13	0.14	0.01
S5	Chard	0.36	2.16	0.59	35.47	8.85	0.59	4.76	15.13	1.05	0.76
	Celery	0.19	0.43	0.25	19.42	3.86	0.22	0.82	7.70	0.61	0.17
	Arugula	0.14	0.47	0.18	21.25	3.00	0.51	0.80	3.57	0.63	0.08
	Leek	0.07	0.17	0.09	5.59	1.23	0.12	0.32	2.58	0.19	0.02
	Dill	0.04	0.12	0.07	3.83	0.66	0.09	0.27	1.50	0.15	0.01
S6	Chard	0.39	1.71	0.14	58.77	6.64	0.13	3.96	7.27	0.72	0.11
	Celery	0.15	0.50	0.19	21.00	3.14	0.27	1.17	7.38	0.58	0.07
	Arugula	0.15	0.54	0.28	34.83	3.12	0.61	0.86	9.22	0.60	0.06
	Leek	0.04	0.13	0.07	9.01	0.85	0.07	0.26	2.19	0.21	0.02
	Dill	0.04	0.14	0.05	5.16	0.69	0.05	0.23	1.22	0.15	0.01

Table 7 shows DIM values. The values of daily metal consumption in vegetables were within the RfD limits, except for Cd from Chard in sites 1,2,3,5 and 6, Pb from Chard in sites 1,2,3,4 and 5, and Arugula and

Celery in sites 2 and 4, and Mn from Chard in sites 2,3,4,5 and 6. These studies imply that consuming these may harm people. Singh et al. (2010), found Ni, Cd, and Pb in wastewater-irrigated vegetables exposed populations near Varanasi (India) to health hazards. research by Gupta et al. (2012) in Titagarh (India) stated that Ni, Cd, and Pb contaminated vegetables pose a health risk.. Another study also published in Iran (Sanandaj City) by (Maleki and Zarasvand, 2008) Confirmed that the daily intakes of Cd and Pb from ingesting vegetables irrigated with wastewater exceeded the acceptable oral reference limits.

3.5. Non- Carcenogenic risk:

3.5.1. Target Hazard Quotient

Because measuring the exposure level is critical, the pathways of exposure to the target species are utilized to identify the health risk of a contaminant. There are several routes via which individuals are exposed to potentially harmful metals, and eating plants polluted with such elements may harm human health (Alsafran et al., 2021). Table 8 displays the results of calculating the THQ to evaluate the health risk of metals intake by vegetable consumers in the studied sites. The THQ, the ratio of the computed dose of a pollutant to a reference dose level, is used to evaluate the dangers to adult populations from eating tainted vegetables. Toxicological Hazard Quotient (THQ) > 1 indicates an increased risk of illness among those exposed. The total hexavalent cations (THCs) of As, Cd, and Pb were found to be greater than unity in all vegetables except sites 2 and 4 for As the THQ< 1 while Al in sites 1,4,6 and Mn in all sites from Chard vegetables the THQ > 1,reflecting the serious potential health risks associated with the consumption of all vegetables, especially Chard. This data indicated that residents of the region may be at risk for poor health effects from As, Cd, and Pb intake from all veggies and Al and Mn ingestion from Chard. Many previous studies confirmed such observation (Adedokun et al., 2016, Hawrami et al., 2020, Latif et al., 2018, Rezapour et al., 2019, Sayo et al., 2020)

3.5.2. Hazard Index:

To assess the possible risks they bring to human health, the HI was utilized since it shows how everything acts together. Vegetable eating is shown to increase metal HI in Table 8. Noncarcinogenic adverse health effects are present at an alarmingly high level, as shown by the HI ranges of 73.99–51.35, 37.03–19.61, 32.26–20.67, 8.38 – 5.08, and 5.40 – 4.70 for Chard, Celery, Arugula, Leek, and Dill across six locations. Table 8. Chard, Celery, Arugula, Leek, and Dill were found to have HI values for As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn, and Ag which were much over recommended levels. This suggests that people living in the region under investigation are at risk of experiencing adverse health effects, and that measures should be taken to lower heavy metal concentrations and safeguard the local population. Our HI findings are consistent with those of previous investigations. (Hussain and Qureshi, 2020)

Table 8: Estimated, THQ, and HI. for metals

Sites	Type of vegetables	THQ As	THQ Cd	THQ Cr	THQ Al	THQ Pb	THQ Ni	THQ Mn	THQ Fe	THQ Zn	THQ Ag	HI
S1	Chard	12.11	17.76	0.00	1.15	17.95	0.30	1.10	0.42	0.04	0.42	51.26
	Celery	4.51	5.14	0.00	0.17	8.47	0.08	0.33	0.08	0.02	0.81	19.61
	Arugula	4.81	5.01	0.00	0.44	11.29	0.14	0.32	0.17	0.01	0.19	22.38
	Leek	1.33	1.73	0.00	0.09	3.09	0.01	0.09	0.04	0.01	0.30	6.69
	Dill	1.02	1.23	0.00	0.06	2.07	0.04	0.10	0.03	0.01	0.16	4.71
S2	Chard	1.22	24.57	0.00	0.85	26.35	0.29	1.36	0.26	0.04	1.13	56.07
	Celery	4.25	7.06	0.00	0.36	11.01	0.22	0.61	0.17	0.04	0.81	24.55
	Arugula	3.19	7.32	0.01	0.33	19.39	0.25	0.73	0.15	0.02	0.79	32.19
	Leek	0.75	1.79	0.00	0.09	2.72	0.08	0.14	0.03	0.01	0.05	5.66
	Dill	1.19	1.32	0.00	0.06	2.15	0.05	0.10	0.03	0.01	0.05	4.96

S3	Chard	13.82	27.47	0.00	0.44	27.51	0.31	2.32	0.17	0.05	1.90	73.99
	Celery	5.09	6.12	0.00	0.20	10.04	0.47	0.38	0.10	0.02	0.42	22.86
	Arugula	3.73	6.83	0.00	0.27	10.56	0.31	0.40	0.11	0.03	0.19	22.42
	Leek	1.39	2.67	0.00	0.07	3.25	0.05	0.14	0.04	0.01	0.06	7.68
	Dill	1.03	1.54	0.00	0.05	2.59	0.04	0.08	0.02	0.00	0.03	5.40
S4	Chard	16.03	13.04	0.00	1.19	30.80	0.21	1.39	0.23	0.04	0.22	63.15
	Celery	10.41	3.87	0.00	0.35	21.05	0.20	0.33	0.18	0.02	0.09	36.52
	Arugula	4.22	5.92	0.00	0.41	9.23	0.39	0.31	0.16	0.02	0.18	20.86
	Leek	0.92	1.39	0.00	0.09	2.46	0.03	0.07	0.04	0.01	0.06	5.08
	Dill	1.05	1.45	0.00	0.06	1.99	0.03	0.08	0.02	0.01	0.03	4.70
S5	Chard	11.18	26.95	0.00	0.44	27.67	0.37	1.80	0.27	0.04	1.90	70.64
	Celery	5.90	5.43	0.00	0.24	12.06	0.14	0.31	0.14	0.03	0.42	24.68
	Arugula	4.23	5.90	0.00	0.27	9.36	0.32	0.30	0.06	0.03	0.19	20.66
	Leek	2.04	2.13	0.00	0.07	3.83	0.08	0.12	0.05	0.01	0.06	8.38
	Dill	1.09	1.54	0.00	0.05	2.07	0.06	0.10	0.03	0.01	0.03	4.97
S6	Chard	12.14	21.31	0.00	0.73	20.75	0.08	1.50	0.13	0.03	0.28	56.96
	Celery	4.83	6.29	0.00	0.26	9.81	0.17	0.44	0.13	0.02	0.17	22.14
	Arugula	4.75	6.72	0.00	0.44	9.76	0.38	0.33	0.16	0.02	0.14	22.70
	Leek	1.21	1.62	0.00	0.11	2.64	0.04	0.10	0.04	0.01	0.04	5.82
	Dill	1.23	1.71	0.00	0.06	2.17	0.03	0.09	0.02	0.01	0.03	5.35

3.6. Carcinogenic risks:

Arsenic, cadmium, and chromium are all "carcinogenic to humans" based on the carcinogenic risks (CR) established by the International Agency for Research on Cancer (IARC), since these elements may promote both noncarcinogenic and carcinogenic effects depending on exposure levels.(Loomis et al., 2018) The findings of estimating vegetable intake are shown in Table 9. As, Cd, and Cr CR values varied from 0.44×10^{-3} to 9.61×10^{-3}, 1.22×10^{-3} to 27.47×10^{-3}, and 0.12×10^{-3} to 7.10×10^{-3} in all vegetables and at all locations, respectively.Table-9. Due to the fact that the CR values for As, Cd, and Cr are above the threshold value (CR > 104), these elements may represent a cancer risk to adults who consume the examined vegetables (Chard, Celery, Arugula, Leek and Dill). The TCR for the present study ranged from 1.98×10^{-3} to 37.57×10^{-3} in this research, with the highest TCR observed at site 3 (wastewater) for Chard and the lowest TCR reported at site 1 for Dill. In an investigation of all veggies, Bian et al. (2016) observed considerably greater CR and TCR than the permissible threshold and concluded that As, Cd, and Cr in the research region presented cancer risks.. Gebeyehu and Bayissa (2020) TCR values for As and Cd in other vegetables were found to be over the recommended threshold, suggesting that exposure to these elements may entail cancer risks. Consuming (Chard, Celery, Arugula, Leek, and Dill) cultivated in Erbil agricultural fields provides a potential cancer risk to the adult population because to the presence of As, Cd, and Cr.

Table 9: Estimated, CR, and TCR.for metals.

Cancer risk(CR) and Target cancer risk(TCR) $*10^{-3}$					
Sites	Type of vegetables	CR. As	CR. Cd	CR.Cr	TCR
S1	Chard	7.26	6.75	2.17	16.18
	Celery	2.71	1.95	0.47	5.13
	Arugula	2.88	1.90	1.09	5.88
	Leek	0.80	0.66	0.21	1.66
	Dill	0.61	0.47	0.14	1.22
S2	Chard	0.73	9.34	1.81	11.88
	Celery	2.55	2.68	1.16	6.39
	Arugula	1.91	2.78	2.69	7.38
	Leek	0.45	0.68	0.33	1.45
	Dill	0.71	0.50	0.23	1.44
S3	Chard	8.29	10.44	1.81	20.54
	Celery	3.06	2.33	0.89	6.28
	Arugula	2.24	2.59	1.13	5.97
	Leek	0.83	1.02	0.36	2.21
	Dill	0.62	0.58	0.63	1.84
S4	Chard	9.62	4.96	2.04	16.61
	Celery	6.25	1.47	1.43	9.15
	Arugula	2.53	2.25	1.06	5.84
	Leek	0.55	0.53	0.27	1.36
	Dill	0.63	0.55	0.14	1.32
S5	Chard	6.71	10.24	2.46	19.41
	Celery	3.54	2.06	1.03	6.64
	Arugula	2.54	2.24	0.73	5.51
	Leek	1.22	0.81	0.37	2.40
	Dill	0.66	0.59	0.28	1.52
S6	Chard	7.28	8.10	0.57	15.95
	Celery	2.90	2.39	0.78	6.07
	Arugula	2.85	2.55	1.15	6.55
	Leek	0.73	0.61	0.30	1.65
	Dill	0.74	0.65	0.22	1.61

4. Conclusion:

pH, EC, TDS, Hardness, Ca, Cl, $SO_4^{=}$, PO_4^{-3}, NO_3^{-}, Na, and K in the studies samples were below the Food and Agriculture Organization's recommended limits for irrigation water. Alkalinity and Mg^{++} were above FAO levels. In addition, the highest value of K^+ at just three locations of waste water exceeds the FAO-recommended limit, but the maximum value of K^+ at three sites of well water is lower than stated by FAO. Except for Cd and As, which were found significant quantities in site 2, the majority of metals had higher amounts in wastewater sites. Ag, Al, Cr, Fe, Mn, Ni, Pb, and Zn concentrations in all places tested are below the recommended limit for irrigation, however Cd and As concentrations are those published by the US EPA and FAO. Al, Fe, and Ag were below WHO/ FAO permissible limit, however the total quantity of metals found in soils irrigated with wastewater and well water was above WHO/ FAO restrictions. The amounts of heavy metals in crops irrigated with wastewater are greater than in vegetables irrigated with well water. As, Cd, Cr, Pb, and Ag levels in all investigated plants exceeded WHO/FAO acceptable limits. Ni, Mn, Fe, and Zn concentrations in all investigated locations and vegetables did not exceed FAO/WHO guidelines. Chard, Celery, and Arugula have higher levels of heavy metals than leeks and dill. All metal BCF values in various veggies were less than 1. This revealed that the veggies absorbed just the metals, but thankfully did not accumulate heavy metals. Ingestion of As, Cd, and Pb in all vegetables, and Al and Mn in Chard, owing to the eating of vegetables grown in this region, may offer health risks to local residents, according to the findings of this research. The CR values for As, Cd, and Cr above the threshold value ($CR > 10^{-4}$), indicating that these elements may provide a cancer risk to adults who consume the examined vegetables (Chard, Celery, Arugula, Leek and Dill). Consumption of vegetables cultivated in close proximity to municipal waste disposal facilities and well water in the studied area has the potential to put human's health at risk; Reducing the use of pesticides by farmers, enforcing the liquidation of oil derivatives by corporations, and taking strong judgments by government authorities are all important to decrease environmental pollution, and the construction of the stations to treat sewage water however, this hypothesis has to be confirmed by an exhaustive dietary survey that takes into account a wide variety of foods .

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Table 2:Physico - chemical properties of water samples gathered from study sites.

mg/l														
K	Na	PO4	NO3	SO4	Cl	Mg	Ca	Alkalinity	T.H	TDS	EC(µs/cm)	pH	Type of water	No.
6.16	40.25	0.46	17.6	99.33	9.22	34.99	38.48	336	240	517.76	809	7.63	Waste water	S1
0.53	32.49	0.04	43.31	30.67	32.61	65.61	72.14	320	450	689.92	1078	7.86	Well water	S2
6.01	29.66	0.2	14.09	100.67	9.93	44.71	36.87	362	276	536.96	839	7.84	Waste water	S3
6.6	30.46	0.24	15.99	102.76	11.34	45.08	37.88	365	280	553.6	865	7.65	Waste water	S4
0.83	26.84	0.04	33.77	36.67	59.56	89.91	40.08	434	470	602.24	941	7.89	well water	S5
1.2	42.37	0.07	42.21	24.67	55.3	73.39	15.23	360	340	616.32	963	7.92	well water	S6
3.56	33.68	0.18	27.83	65.80	29.66	58.95	40.11	362.83	342.67	586.13	915.83	7.80	Mean	
1.11	2.32	0.06	5.04	14.42	8.66	7.78	6.80	14.56	36.00	23.63	36.91	0.05	SE	
0.76	0.17	0.85	0.44	0.54	0.72	0.32	0.42	0.10	0.26	0.10	0.10	0.01	CV%	
0–2	0–920	0-2	50	575	70	9.4–13.5	0–400	500	500	0–2000	700-<3000	6.5–8.6	FAO	

SE:Standard error; CV: Coefficient of variation, Permissible limits for irrigation water are set by the Food and Agriculture Organization (FAO)

Table 5: Concentrations of metals in vegetable samples from six sites

Sites	Type of Vegetables	As	Cd	Cr	Al	Pb	Ni	Mn	Fe	Zn	Ag
S1	Chard	7.35±0.82	26.95±2.33	9.88±1.01	1753±9.8	109±3.53	9.16±0.21	55.00±0.56	448±6.23	19.6±8.34	3.2±0.11
	Celery	6.02±0.76	17.16±1.27	4.71±0.78	573±7.65	113±6.86	5.28±4.04	36.10±11.06	196±8.98	18.1±6.36	13.49±9.05
	Arugula	7.24±0.76	18.85±0.63	12.36±1.3	1645±9.63	170±5.77	10.76±0.62	39.67±1.44	445±9.65	15.58±1.01	3.62±0.06
	Leek	5.03±0.70	16.35±0.64	5.99±0.87	869±7.98	117±2.82	2.47±0.09	28.04±1.49	281±4.98	30.59±0.86	14.25±1.48
	Dill	5.09±0.71	15.3±2.3	5.26±0.84	686±6.65	103±7.1	9.19±0.12	40.33±10.56	264±3.43	19.9±6.00	10.25±2.76
S2	Chard	0.74±0.45	37.3±2.56	8.24±0.89	1290±9.34	160±1.54	8.7±0.92	67.9±1.32	277±1.76	16.6±1.21	8.2±2.04
	Celery	5.67±0.92	23.56±4.56	11.63±0.92	1213±5.5	147±2.75	14.7±0.28	67.3±61.45	443±2.08	40.13±2.6	13.59±0.86
	Arugula	4.8±0.87	27.55±1.34	23.10±7.49	1251±7.07	281±3.87	18.9±1.4	90.9±2.82	407±3.53	27.9±1.26	14.41±1.08
	Leek	2.84±0.95	16.9±0.70	9.27±0.48	833±5.65	103±1.87	14.25±0.49	43.95±6.71	212±1.41	33.55±1.48	2.6±0.06
	Dill	5.92±0.91	16.5±1.3	8.46±0.91	805±2.1	107±1.65	12.6±0.92	40.8±0.34	251±0.23	23±0.54	3.19±0.76
S3	Chard	8.39±0.69	41.7±2.65	8.23±1.09	673±3.56	167±2.78	9.5±0.56	116±2.67	180±2.45	21±2.27	14.9±1.08
	Celery	6.8±0.45	20.43±1.00	8.93±2.45	666±11.59	134±12.2	31.65±.062	42.23±4.95	245±3.08	21.76±4.89	7.01±0.45
	Arugula	5.62±0.34	25.7±1.04	30.40±1.29	1020±5.43	159±1.67	23±0.98	49.4±1.76	293±5.46	34.2±0.93	3.6±0.49
	Leek	5.26±1.40	25.3±3.39	10.15±0.21	704±7.07	123±2.82	9.33±1.50	45.05±0.63	237±2.12	26.25±0.93	2.61±0.07
	Dill	5.15±0.47	19.13±2.40	23.71±0.86	636±5.65	129±2.36	10.04±0.93	34.9±6.78	207±3.53	16.3±1.01	1.96±0.08
S4	Chard	9.73±0.62	19.8±1.01	9.28±0.79	1810±6.76	187±1.43	6.35±0.12	69.6±1.45	243±2.98	17.5±0.74	1.55±0.065
	Celery	13.9±0.43	12.9±0.95	14.3±0.76	1180±6.87	292±2.75	13.65±1.79	36.3±3.87	430±2.86	16.5±0.83	1.56±0.023
	Arugula	6.36±0.86	22.3±1.13	11.95±0.35	1551±9.19	139±7.07	29.5±1.07	38.45±2.0	417±7.02	26.45±4.87	3.45±0.43
	Leek	3.50±0.58	13.2±2.96	7.74±0.63	850±7.07	93±6.22	6.54±0.71	23.1±1.27	241±4.24	22.03±2.61	2.81±0.31
	Dill	5.21±1.68	18.02±4.73	5.23±2.23	750±4.24	99±2.82	7.01±0.07	34.68±2.73	176±2.07	21.5±2.73	1.58±0.65
S5	Chard	6.79±1.30	40.91±3.51	11.2±1.27	673±7.77	168±5.66	11.16±1.47	90.35±3.46	287±3.54	19.97±1.87	14.4±0.87
	Celery	7.88±0.60	18.13±0.21	10.36±0.34	810±4.94	161±4.97	9.38±0.65	34.4±4.88	321±4.24	25.43±2.19	7.01±0.04
	Arugula	6.37±0.98	22.2±4.66	8.3±4.95	1000±1.41	141±2.83	24.04±2.73	37.7±1.84	168±2.12	29.6±2.40	3.6±0.07
	Leek	7.71±1.59	20.2±4.91	10.41±0.37	662±2.88	145±4.05	14.68±2.56	37.8±2.36	305±4.95	22.46±3.13	2.61±0.94
	Dill	5.45±1.28	19.2±4.39	10.52±0.65	596±4.24	103±2.53	14.26±2.34	41.45±2.19	233±5.66	23.16±5.47	1.96±0.47
S6	Chard	7.37±0.38	32.35±2.89	2.59±0.08	1115±7.07	126±7.77	2.44±0.01	75.1±4.52	138±12.72	13.7±2.05	2.1±0.02
	Celery	6.45±0.57	21±2.33	7.82±6.26	876±6.36	131±5.68	11.3±0.98	48.7±3.46	308±8.14	24.3±2.86	2.83±0.32
	Arugula	7.15±0.53	25.3±0.28	12.95±0.35	1639±10.61	147±6.36	28.5±0.36	40.4±2.05	434±21.21	28.1±4.45	2.69±0.04
	Leek	4.6±0.31	15.3±2.09	8.6±0.51	966±6.01	100±4.45	8.49±0.35	30.6±1.6	259±10.5	24.3±5.50	2.05±0.22
	Dill	6.15±1.76	21.25±1.90	8.2±0.84	804±10.61	108±4.24	8.04±0.09	36.2±3.53	190±6.36	23.2±5.16	1.83±0.06