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THE TRANSPORTATION OF HEAVY METALS THROUGH FOOD CHAIN CAUSED BY INDUSTRIAL EFFLUENTS IN KWASHE INDUSTRIAL AREA, KURDISTAN REGION, IRAQ

RONAK ABDULAZEEZ MESHABAZ

University of Zakho, Faculty of Science, Environmental science dept., Kurdistan Region, Iraq.

MUSTAFA ISMAIL UMER

Soil & Water Department, College of Agricultural Science Engineering, Duhok University, Kurdistan Region, Iraq.

Abstract:

The objectives of this study were to investigate whether heavy metals are transported from industrial effluent to forage, sheep, and human through food chain and evaluation of the potential health risks associated with heavy metal pollution. For the analysis of metals, an atomic absorption spectrophotometer was used. The results showed that sites had significant ($P<0.01$) impact on heavy metal concentration in effluent, soil and forage. The data of selected heavy metals in animals were higher in wool samples than the blood samples. It was also found that sex in human samples were significantly ($P<0.01$) effect on the level of metals; as it was illustrated that all metals in male blood were considerably higher than female blood. Health risk index values were higher than one among the majority of metals which indicate that the land is not suitable for grazing animals.

Keywords: effluent, food chain, forage, heavy metals, sheep, soil

1. INTRODUCTION

Rapid industrialization has a negative impact on the environment qualities in different ways by releasing a significant volume of effluent as wastewater, which poses substantial environmental issues [1]. In developing countries, an alternate source for irrigating plants is wastewater. However, it is illegal in many countries because untreated industrial effluents contains many toxic metals and has hazardous effects on plants, animals, and human [2], [3].

Therefore, the potential harmful metal content of soil and forage is significantly increased by prolonged use of treated and untreated effluent in land, and these metals are further passed to the food chain, posing numerous health risks to people[3], [4].

The trace metals can affect approximately 25 cm depth of soil, which is an accumulation in soil and plants due to continues irrigation with wastewater [5]. High level of metals in soil and plants is reflected in animal and humans consuming these plants.

As a result, metal levels in animal and human tissues may exceed the acceptable limit [6]. According to the World Health Organization (WHO), the standard heavy metal concentration was beyond the permissible level and dangerous to both human and animal health mention some of his finding [7].

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There are numerous findings around the world demonstrating significant levels of heavy metals in the production of ruminant raised in industrial contaminated environments [8], [9], [10], [11], [12]. Moreover, Toxic effects of heavy metals in animals depend on extent of exposure, type of heavy metal and its form, age, sex, physiological and nutritional status of exposed animal and route of poisoning [7].

The main causes of toxic heavy metal accumulation in humans are food chain pathways. Age and sex are two innate characteristics that affect the levels of heavy metals in human blood [13]. Research confirms that toxicity of these metals could cause a variety of illnesses in human, including damaged mental and central nervous system, destruction to the liver, kidneys and lungs. Long-term exposure may also Parkinson's disease, Alzheimer's disease, and muscular dystrophy [14].

The most suitable human samples often used in metal analyses are blood and hair. The concentrations of heavy metals in human blood have been determined using blood samples [14], [15], [16], [17]. The maximum permissible levels (MPL) of heavy metals in foodstuffs have been established by the Food and Agricultural Organization of the United Nations (FAO), WHO, United States Environmental Protection Agency (USEPA), and the Agency for Toxic Substances and Disease Registry (ATSDR).

These organizations have also provided some methods for assessing health risks. Numerous studies have recently been examined the potential health risks of heavy metal contamination in soil and plants in various regions based on these techniques [18], [19], [20], [21], [22]. However, little studies have been conducted to assess the transportation of heavy metal contamination on the environment, their impact on animal health, and especially their influence on local inhabitants after the passage of metal via the food chain. Therefore, the objectives of this study were to investigate whether heavy metals are transported from industrial effluent to forage, sheep, and human through food chain and evaluation of the potential health risks associated with heavy metal pollution.

2. MATERIALS AND METHODS

2.1. Study Area

The study was performed in the Kwashe Industrial Area (KIA) at Summel district, Kurdistan Region, Iraq (36°59'04.2" N 42°47' 50.8" E), 25 kilometers Northwest of Duhok province (Fig. 1). More than 150 factories are based at KIA, with approximately fifty crude oil refineries. Around one million letters of untreated wastewater are released into the ecosystem daily [23]. Three sites with high industrial accumulated waste at KIA were indicated for samples collecting.

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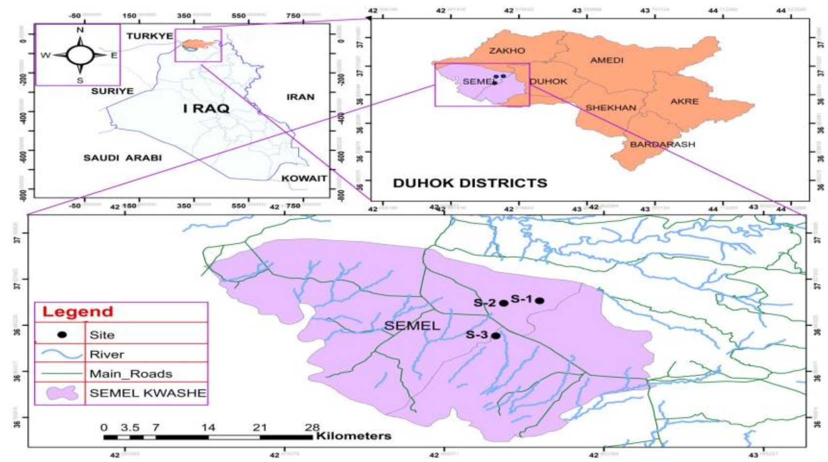
Figure (1): The location of study area and site sampling



2.2. Samples Collection

Samples of effluent, soil, forage, sheep (blood and wool) and human blood were collected from three different locations of KIA. Total 27 Sample of effluent were collected from discharge point, standard collection techniques were used as described by [24]. Fresh blood samples were collected from jugular vein of 20 Awassi sheep 2-3 years around KIA.

Steel scissors were used to collect approximately 5 g of wool samples from the neck of the (20) Awassi sheep. 20 human volunteers (10 men and 10 women) between the ages of 25 and 40 who resided in a polluted area (KIA) were participated in the study.

2.3. Preparation of Samples

The sample preparation process consists of four sub-steps including the digestion, dilution, filtration of the samples, and analyzes of heavy metals. Effluent, Soil and grass samples digested according to [25]. Protocol for blood sample digestion was given by Richards, taking a 0.5 mL serum sample and combining it with 10 mL nitric acid and 5 mL perchloric acid in a digestion flask.

The solution was warmed until it became colorless. Samples of sheep wool were analyzed according to [26]. The concentration of heavy metals in the samples were determined by atomic absorption spectroscopy AAS (Perkin–Elmer, PinAAcle 900 AAS Consumables and Supplies).

2.4 statistical analyses

The gathered data submitted to SPSS software [27], in order to analyze it statistically. Factorial analysis (two-way ANOVA with interaction) was applied to illustrate the effects of location, effluent, soil and forage. Analysis of variance (one-way ANOVA) was applied to compare among serum and wool of the studied samples of animals. Also, independent samples t-test was applied to compare between the males. Moreover, the means within both ANOVA ways were separated using Dancan's multiple range tests [28].

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2.5 Bio-concentration factor (BCF)

To determine (mg/kg) of metal transport from soil to forage that grown on this soil BCF was applied according [29].

BCF= [M]forage / [M]soil, Where [M]forage is the concentration of metal in forage (mg/kg) and [M]soil is the concentration of metal in soil (mg/kg).

Bio-concentration factor (BCF) for blood was determined following [30].

BCF= Metal contain in serum of sheep/ metal level in forage

2.6 Pollution load index (PLI)

PLI for a specific location was calculated to determine the level of metal contamination of the soil by metal concentration of soil against typical metal contents [31].

PLI = C soil /C reference value

C soil= concentration of metal in investigated soil

C reference= reference value of the metal in soil

The reference value of Cd, Cu, Pb, Ni, Fe, Cr, Zn and Co was 1.49, 8.39, 8.15, 9.06, 56.90, 9.07, 44.19 and 9.1 mg/ kg respectively

2.7 Enrichment factor (EF)

Buat-Menard and Chesselet [32] present the formula for the enrichment factor.

$$\text{Enrichment factor (EF)} = \frac{\text{(Conc. of metal in plant/Conc. of metal in soil) sample}}{\text{(Conc. of metal in plant/Conc. of metal in soil) standard}}$$

Table (1): Oral reference dose mg/kg/day and Stander concentration of metal in soil and forage mg/kg

Metal	Oral reference dose	Stander in soil	Stander in fodder	References
Pb	0.0035**	8.15	5	[33]
Cu	0.04**	8.39	73.3	[34]
Co	0.043*	44.19	0.60	[35]
Cd	0.001*	2.8	0.2	[34]
Cr	1.5*	8.15	2	[35]
Zn	0.3*	44.19	60	[35]
Ni	0.02*	9.06	1.5	[33]
Fe	0.041*	56.9	425.5	[35]

*[36], ** [37]

2.8 Daily intake of metal (DIM)

Daily intake of metal was assessed according to [38]

DIM = C factor × C metal × D food intake ⁄ B average weight

Where: C metal is the amount of metals in forages, D food intake is the amount of consumed forages daily, B average weight is the average body weight. C factor is

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conversion factor. DIM of consumed forage was 1.51 (kg per sheep) and the average body weight of sheep was 45 kg. C factor of 0.085 was used to convert the green plant mass to the dry weight [39]

2.9 Health risk index (HRI): By using the health risk index, the degree of the heavy metal hazard is determined was regarded as the relationship between the oral reference dose and the daily intake of metal [36]

HRI= DIM / RfD

DIM = Daily intake of heavy metal RfD = Oral reference dose

If the value of HRI > 1.0 indicates that the health of consumer population is at risk or it is carcinogenic [38]

3. RESULTS AND DISCUSSION

3.1 Concentration of heavy metals in Effluent

The results of heavy metal (Mg/L) in the effluent at three different sites are represented in Table (2). There are significant (P<0.01) differences among metals for each sites. In the current investigation all toxic metal were above permissible limit suggested by [37]. High levels of heavy metals may indicate contamination and may eventually have a negative impact on the ecosystem.

When the findings of this study were compared to those of other similar research, it was seen the values of metals in the present study were higher than the value reported by the [40], [3]. As shown in (Table 2) the maximum concentration of Pb (4.71) was recorded in site I and the minimum level (2.85) were reported at site III Similar observations were obtained by [41]. Furthermore, [42] observed lead in the paint effluent samples ranged between 5.38±1.41 mg/L and 17.21±1.67 mg/L, the excessive use of inorganic lead pigment during manufacture was thought to be the cause of the elevated lead concentration .

Lead concentration in the industrial effluents may have been emitted from a variety of sources, including the mining and transportation industries [41]. The lowest value Cu (5.3 Mg/L) was noticed at the first location then gradually increased toward the highest level (7.08 Mg/L) at third location, while Co concentrations were fluctuated among sampling site. Furthermore, the Cd concentration in effluent ranged from 0.58-3.31(Mg/L).

This result is in accordance with the result of [43], [6]. However, the lower value of Ni and Cd than the present research was founded by [44]. Potentially the presence of Ni in industrial effluents was due to specific industries such as oil, chemicals, steel alloys and vehicle batteries [41]. High Cd levels in this investigation can result from the effluent discharges of the marble, steel, and aluminum sectors as well as mining and metal plating. The Cr values in the effluent were (3.67, 2.43, and 3.37) in site I, II and III respectively.

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These finding are agree with the results of [42]. The concentrations of zinc in the effluent samples were (7.33, 7.89 and 6.93) in three different locations. Similar result has been reported on Fertilizer industrial effluents by [45]. The highest value of Fe (4.76 Mg/L) in effluent samples recorded in site II. This finding is agreed with result of [1].

Table (2): Concentration of some heavy metal (Mg/L) in effluent samples obtained from three different sites in KIA

Heavy metals	Location	Mean	Std. Deviation	Std. Error	Minimum	Maximum	Sig. (p)
Pb	1	4.2256 a	0.408	0.136	3.58	4.71	0.0001
	2	3.6222 b	0.309	0.103	3.12	3.95	
	3	3.2756 c	0.216	0.072	2.85	3.58	
Cu	1	5.3078 c	0.268	0.089	5.02	5.77	0.0001
	2	6.0122 b	0.215	0.071	5.59	6.32	
	3	7.0844 a	0.439	0.146	6.23	7.81	
Co	1	3.5678 a	0.450	0.150	2.83	3.88	0.0001
	2	1.7178 c	0.343	0.114	0.81	1.89	
	3	2.3800 b	0.453	0.151	1.53	2.68	
Cd	1	1.1322 b	0.281	0.093	0.85	1.55	0.001
	2	1.5911 b	0.814	0.271	0.58	2.88	
	3	2.3611 a	0.669	0.223	1.46	3.31	
Cr	1	3.6478 a	0.159	0.053	3.53	3.88	0.0001
	2	2.4322 c	0.094	0.031	2.32	2.59	
	3	3.3378 b	0.458	0.152	2.38	3.86	
Zn	1	7.3367 b	0.314	0.104	6.92	7.85	0.001
	2	7.9822 a	0.771	0.257	6.52	8.85	
	3	6.9300 b	0.382	0.127	6.21	7.61	
Ni	1	.9944 b	0.395	0.131	0.54	1.58	0.0001
	2	1.5956 a	0.275	0.091	1.02	1.89	
	3	.9733 b	0.208	0.069	0.48	1.22	
Fe	1	2.0544 b	0.311	0.103	1.48	2.44	0.0001
	2	4.7633 a	0.553	0.184	3.88	5.42	
	3	2.1533 b	0.469	0.156	1.18	2.89	

Means with different letters **within each heavy metal** differed significantly ($p<0.01$)

3.2 Concentration of heavy metals in soil

In soil sample the mean value of toxic metal are present in table (3), as it is shown, there are significant ($P<0.01$) differences among all the studied metals in each location. The value of Pb, Co, Cr, Zn, Ni and Fe fall within the permissible limit recommended by [35]. Cd concentration in all sampling site exceed the permissible level. The concentration of Cu in site 1 was greater than permissible limit 8.39 (mg/kg). Similar with the current study, [46] indicated that the polluted soil samples had a significantly higher concentration of copper (3.54 to 4.08 mg/kg). Ahmad et al. [33] indicated that Cu levels in contaminated soil irrigated with wastewater were increased, ranging from 2.79 to 4.13. Copper can accumulate in the soil more due to environmental variables like low soil pH and excessive pesticide or insecticide use. Furthermore, Cd in sampling locations was exceeding the stander limit 2.8 (mg/kg). Similar data (3.46 ± 0.01 mg/kg) in recent year has been observed in other study of soil contamination with industrial

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effluents by [47] Lie et al. [22] obtained lower Cd value (0.84 mg/kg) in soil polluted with industrial activates than this study. This could have been caused by a variety of industries incorporated in a study area, such as phosphorus chemicals, leather, active mining or coal and iron processing facilities and application of agrochemicals all of which may contribute to Cd contamination.

Table (3): Concentration of some heavy metal (Mg/Kg) in soil samples obtained from three different sites in KIA

Heavy metals	Location	Mean	Std. Deviation	Std. Error	Minimum	Maximum	Sig. (p)
Pb	1	3.7022 b	0.326	0.108	3.12	4.18	0.0001
	2	5.2000 a	0.514	0.171	3.88	5.55	
	3	4.9967 a	0.249	0.083	4.65	5.36	
Cu	1	9.6767 a	0.896	0.298	8.18	10.32	0.0001
	2	7.6367 b	0.986	0.328	6.15	8.54	
	3	6.7478 c	0.809	0.269	6.14	8.19	
Co	1	1.4867 b	0.325	0.108	1.12	2.12	0.006
	2	1.9644 a	0.218	0.072	1.58	2.18	
	3	1.8744 a	0.346	0.115	1.35	2.45	
Cd	1	12.8700 b	3.208	1.069	10.19	18.24	0.0001
	2	17.0200 a	0.408	0.136	16.37	17.58	
	3	18.0256 a	0.529	0.176	17.11	18.58	
Cr	1	2.3356 a	0.171	0.057	2.14	2.55	0.0001
	2	1.6144 b	0.353	0.117	1.16	2.18	
	3	1.7656 b	0.186	0.062	1.36	1.92	
Zn	1	10.9511 b	0.651	0.217	10.12	11.88	0.0001
	2	15.2211 a	0.330	0.110	14.69	15.78	
	3	15.2333 a	1.022	0.340	14.13	17.45	
Ni	1	1.7456 a	0.239	0.079	1.16	1.88	0.116
	2	1.5644 a	0.214	0.071	1.16	1.74	
	3	1.5644 a	0.145	0.048	1.36	1.83	
Fe	1	48.9678 b	5.157	1.719	41.55	59.14	0.0001
	2	45.4600 c	2.559	0.853	40.99	48.67	
	3	59.8356 a	1.085	0.361	58.49	61.12	

3.3 Concentration of heavy metals in forage

The mean values of heavy metal in forage that grow in polluted soil with effluent are present in table (4). In the current work the concentration of metals in forage differ significantly ($P<0.01$) among the location except Cd and Fe had non-significant effect. The outcome in table (1) also showed a higher concentration of all the detected heavy metals under investigation in forage sample than in the permissible level suggested by [35] except Cd, Fe and Zn. This is due to the fact that plant absorbs metal from the soil. Metal compounds are accumulated by plants in their tissues at levels higher than those found in soil (bio-accumulation of metals). Different plants exhibit different levels of heavy metal buildup in their tissues as a result of a variety of factors such as age of plant, the biochemical function of metal, and the type of plant. The amount of organic matter in the soil, human impacts, and environmental contamination are some other considerations [5].

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The water-soil-plant system metal take-up, toxicity, and detoxifying components have all been extensively investigated by a variety of researchers in the previous [48], [49], [50]. Additionally, (Table. 2) demonstrates that among all the forage samples, Fe had the highest concentration values followed by Cu. The highest level of Fe (89.33 mg/kg) at sites 3 was observed. However, the Fe concentrations in sampling site were lower than the permissible limit (425.5). This finding was similar to the observation of [51] and lower than finding of [47] .In the present work Cu concentration in forage samples ranged from 16.99 to 21.55 mg/kg similar values have been reported earlier by [51] who founded highest concentration of Cu (29.33) in sorghum forage grown in effluent polluted soil because sorghum has a high potential for phytoremediation.

Table (4): Concentration of some heavy metal (Mg/Kg) in forage samples obtained from three different sites in KIA

Heavy metals	Location	Mean	Std. Deviation	Std. Error	Minimum	Maximum	Sig. (p)
Pb	1	6.0767 b	0.519	0.173	5.32	6.78	0.0001 **
	2	6.3089 b	0.455	0.151	5.78	6.92	
	3	7.1556 a	0.490	0.163	6.78	7.99	
Cu	1	16.9944 c	0.248	0.082	16.55	17.32	0.0001 **
	2	18.8267 b	1.302	0.434	17.12	20.33	
	3	21.5522 a	2.413	0.804	17.17	25.12	
Co	1	1.9667 b	0.028	0.009	1.91	1.99	0.035 *
	2	2.4056 a	0.508	0.169	2.02	3.12	
	3	2.2433 ab	0.293	0.097	2.03	2.99	
Cd	1	6.9500 a	0.555	0.185	6.45	7.68	0.149 NS
	2	6.9244 a	1.680	0.560	2.56	7.99	
	3	7.7967 a	0.305	0.101	7.35	8.15	
Cr	1	3.0922 b	0.102	0.034	3.01	3.33	0.0001 **
	2	3.2944 b	0.291	0.097	3.01	3.88	
	3	3.8456 a	0.355	0.118	3.19	4.15	
Zn	1	7.4889 b	0.340	0.113	6.91	7.82	0.004 **
	2	7.8689 a	0.467	0.155	7.16	8.78	
	3	8.1356 a	0.260	0.086	7.84	8.67	
Ni	1	2.0567 a	0.298	0.099	1.61	2.67	0.049 *
	2	1.6267 b	0.191	0.063	1.42	1.98	
	3	2.0911 a	0.664	0.221	1.33	2.87	
Fe	1	79.8833 a	3.238	1.079	71.67	82.80	0.129 NS
	2	76.8400 a	21.931	7.310	37.45	88.85	
	3	89.3344 a	4.633	1.544	80.18	98.12	

Means with different letters **within each heavy metal** are differed significantly

**= $p<0.01$; *= $p<0.05$; NS= Non-significant

3.4 Heavy metal in wool and blood of animals

Heavy metal levels of blood serum and wool samples collected from Awassi sheep at pasture KIA are present in table (5). The metals concentrations in serum of current animals were higher than the normal range except Fe with in the safe range. Moreover, result showed that the selected heavy metals were higher in wool samples than the

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blood samples. The amount of heavy metal in wool might be an important indicator of the accumulation of heavy metal in an animal body [34]. Tuncer et al. [12] concluded that wool could be used to measure trace elements instead of serum for the welfare of animals. The Pb concentration in wool sample were ranged from 5.86 to 6.99 mg/kg and higher than the serum concentration(4.596Mg/L) which was greater than the safe limit 0.25 mg/l reported by [12]. The recorded data is associated with acute Pb toxicity; it means the grazing of sheep in KIA is exposure to potentially very high Pb levels in soils and forage. Animals absorb more lead and cadmium due to their increased fat and decreased protein content of meat as they get older [52]. Similar with the current result, [53] observed Pb concentration (2.1975-2.23 mg/kg) in blood samples of animals feed on contaminated forage. Smith et al. [54] reported the highest Pb concentrations in the blood of sheep grazing with metal contamination areas. The Present wool values were quite above the values of [31] reported for sheep that had grazed on Pb-contaminated areas (3.64 mg/kg).

The average of Cu in wool was 14.25 and animal blood was (6.085) which was greater than the safe level (0.02mg/l) in healthy sheep recommended by [31]. Our results are in agreement with the studies by [55]. A study by [56] indicates the amount of copper in sheep blood dramatically rose after grazing in metal-contaminated grassland adversely impacted the animal growth and development.

The Cd concentration in wool and serum were (3.298 mg/kg and 2.77 Mg/L) respectively. The permissible limit for Cd in ruminant diets is 0.05 mg/kg. High levels of Cd cause toxicity, lack of appetite, and slower growth in sheep [57]. The consumption of pasture grown on cadmium-contaminated soil may be associated to the greater concentration of cadmium in sheep wool and blood. Similar observations for Sheep grazing near the mining site (3.9 mg/kg) and in rural (2.9 mg/kg) portions were recorded by [58]. Hussain et al. [34] also found that the level of cadmium has higher in sheep wool than in sheep blood. The present findings were significantly higher than the results by [59]. The average concentrations of Cr were 0.88 and 0.63 in sheep wool and serum respectively. According to our data, increased serum and wool Cd could be a result of the high levels of Cd in forage. Cd can easily penetrate the food chain from plants and animals eating polluted forages.

Cobalt is an essential element for the growth animals, whereas greater concentrations could be dangerous [30]. The Co concentration in investigated sheep wool ranged from 1.96 to 3.99 and serum was 0.629 mg/l. This observation agree with value of [60] , which recorded the highest concentration of Cobalt in the wool of Awassi breed sheep (2.31 mg/kg) due to the degree of environmental contamination. Moreover, according to [61] male lambs in Turkey had Co levels in wool between 0.59 and 1.36 mg/kg. The same data (0.63±0.17 mg/l) in the blood of sheep feeding on industrial contamination pasture was recorded by [62]. On the other hand, higher Co content in the blood of sheep than those data was observed by [30].

The mean concentration of Zn was 147.12 and 8.789 in wool and blood sample, the blood value of Zn was within the range of permissible limit 1.45 mg/l. This result is agreed with the result of [63], [53], while our findings were higher values of Zn founded

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in sheep blood [64] and wool [65]. Due to mineral supplementation of ruminants at the farms of sample sites, there is a larger accumulation of Zn in wool and serum of animal .The concentration of Ni in sheep wool 1.39 and serum 1.22 Mg/L was higher than the standard limits (0.4 mg/L) recommended by [66]. Ni concentrations in forages and blood of animals eating this forage rise as a result of high concentration in the soil [67].

Iron is the most important component for both people and animals. The majority of Fe is bonded to hemoglobin [68]. The mean Fe in wool was 109.2 and serum Fe levels in investigated sheep were (226.5 mg/l) significantly greater than the reference range (0.9-2.7) recommended by [69]. This finding was in accordance with previous work, [56] observed (219±27.9 mg/l) of Fe level in blood of sheep grazed in metal polluted pasture.

Table (5): Concentration of heavy metals in serum (Mg/L) and wool Mg/Kg of studied animals

metals	parameters	Mean	Std. Deviation	Std. Error	Minimum	Maximum	Sig. (p)
Pb	Serum	4.596 b	0.465	0.104	3.56	5.41	0.0001
	Wool	6.279 a	0.380	0.085	5.87	6.99	
Cu	Serum	6.085 b	0.435	0.097	5.14	6.87	0.0001
	Wool	14.256 a	6.320	1.413	8.22	25.10	
Co	Serum	0.6295 b	0.077	0.010	0.55	0.84	0.0001
	Wool	3.035 a	0.584	0.130	1.96	3.99	
Cd	Serum	2.775 a	0.857	0.191	1.18	3.93	0.0001
	Wool	3.292 a	0.600	0.134	1.99	3.98	
Cr	Serum	0.633 b	0.082	0.018	0.51	0.78	
	Wool	0.8385 a	0.106	0.023	0.58	0.98	0.0001
Zn	Serum	8.789 b	2.211	0.494	7.12	14.12	0.0001
	Wool	147.12 a	48.670	10.880	87.90	198.10	
Ni	Serum	1.2215 a	0.256	0.057	0.96	1.94	0.003
	Wool	1.390 a	0.265	0.059	1.16	1.87	
Fe	Serum	226.50 a	59.028	13.199	156.00	336.00	0.0001
	Wool	109.2 b	4.983	1.114	100.50	120.50	

Means with different letters within each studied heavy metal are differed significantly

3.5 Heavy metals in human blood

An important technique to evaluate the potential of hazardous metal exposure from the environment is by measuring the quantity of heavy metals in human blood [13]. In the current investigation (Table 6) shows the results of the analysis of the amount of heavy metals in blood samples from the chosen participants in relation to gender. It was found that sex were significantly ($P<0.01$) effect on the level of metals; as it was illustrated that all metals in male blood were considerably higher than female blood. Age and sex are two inherent variables that impact the levels of heavy metals in human blood. Results also indicate that all metal in both sex were higher than the safe limit. The Pb concentration in male and female samples were (1.01 and 0.65 Mg/L) respectively. Similarly [13] founded Pb higher in male than in female. Lead can have an impact on body functions, particularly the central nervous system and the cardiovascular system, which can result in mortality [70]

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Cr concentrations in investigated blood were 0.542 and 0.404 in men and women respectively. Cr levels in the human body that are higher than 0.003 mg/kg have been linked to skin irritation, respiratory issues, kidney, stomach, and lung damage, ulcers, and lowered immunity [65]. The level of Cd was 0.283 in male and 0.186 in female. Even at low concentrations, cadmium is a very poisonous metal; meanwhile, Cd pollution harms numerous organs of human body, particularly the kidneys cause significant conditions like pneumonic emphysema, renal cylindrical damage, and kidney stones [71]. The concentration of Cu found 18.39 in male and 16.02 in female were higher than the finding of [72]. However, Zn values in our investigation were higher than [72]. The level of Fe, Co and Ni obtained in current research were (3.96 M and 2.57 F), (0.29 M and 0.18 F) and (0.55 M and 0.43 F) respectively table (7). Different toxic metals may accumulate in the food chain and the human body due to their rapid absorption, poor excretion mechanisms, and long half-lives [73].

Table (6): Compassion between male and female for having heavy metals (Mg/L)

Heavy metals	Gender	Mean	Std. Deviation	Std. Error	Sig. (p)
Lead	Male	1.010 a	0.146	0.046	0.0001
	Female	0.652 b	0.067	0.021	
Copper	Male	18.39 a	0.366	0.115	0.0001
	Female	16.20 b	0.795	0.251	
Cobalt	Male	0.295 a	0.025	0.008	0.0001
	Female	0.184b	0.021	0.006	
Cadmium	Male	0.283 a	0.065	0.020	0.014
	Female	0.186b	0.091	0.028	
Chromium	Male	0.542 a	0.028	0.008	0.002
	Female	0.404 b	0.119	0.037	
Zinc	Male	5.862 a	0.679	0.215	0.004
	Female	4.830 b	0.730	0.231	
Nickel	Male	0.559 a	0.032	0.010	0.0001
	Female	0.435 b	0.044	0.013	
Iron	Male	3.966 a	0.234	0.074	0.0001
	Female	2.573 b	0.485	0.153	

Means with different letters within each heavy metal are differed significantly between both sexes.

3.6 Pollution load index (PLI)

Heavy metals can accumulate in soils after prolonged irrigation with waste water, the indicator of soil metal pollution is PLI. According to this method, soil is regarded as clean or less pollute if the pollution load index value is lower than 1, and consider to be contaminated if it is greater than 1. The range for PLI in the present study was 0.16 to 12.02 (Table 7). In the current study, Cd had the highest PLI value among all metals, demonstrating that Cd may create risk to the environment. These values were in line with that given by [3].

3.7 Bio-concentration factor (BCF)

The ability of various plants to accumulate heavy metals from soil is examined by using bio-concentration factor [33]. The BCF (soil –forage) at the three sites was in the

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following order: Cu>Cr>Fe>Pb>Co>Ni>Zn>Cd (Table 7), the highest BCF was observed for Cu and the lowest for Cd among the three sites. In the current findings, with the exception of Zn and Cd, all other heavy metals levels were **>** 1**.** It should be noted that a bioaccumulation factor of an element over one denotes a significant absorption of that mineral by plants. This might seriously pollute the food that consumer eat, which would be hazardous for their health. These finding is agree with finding reported by [5]. However, these values were higher to those reported by [31]. The accumulating factor is influenced by soil metal availability and mobility as well as physiological characteristics of the plant [22]. As indicate from Fig (1) the highest BCF from forage to sheep blood was found to Fe followed by Zn both metal was above 1, indicating a potential risk.

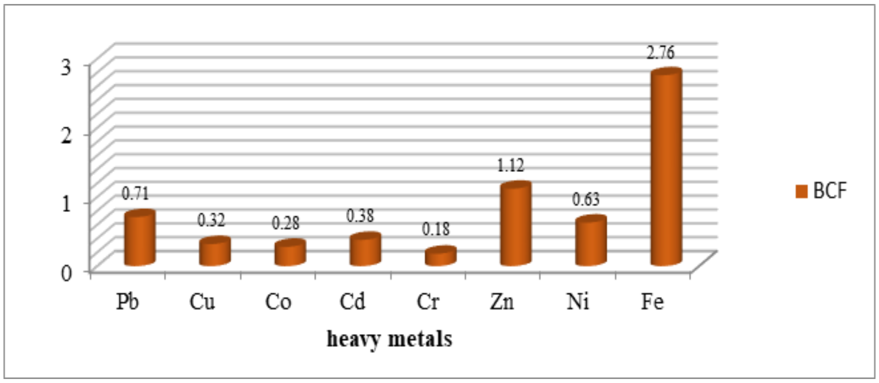

Fig (1): Bio-concentration factor for sheep blood-forage

3.8 Enrichment factor

Sutherland [75] distinguished five classes of pollution based on the EF value; the absence of enrichment (<2), moderate enrichment (2–5), high enrichment (5-20), very high enrichment (20–40), and extremely high enrichment (>40). Therefore, the outcomes of enrichment factors in Table (7) suggested that the examined soils are extremely high enrichment with Co, high enrichment with Cr, Ni and Cd, moderate enrichment with Pb and the absence of enrichment with Zn, Cu and Fe. Highest value of EF was found for Co at the site 1 and lowest for Fe at the site 3. The order of EF at three locations was Co>Cr>Ni>Cd>Pb>Zn>Cu>Fe (Table 7), this observation is in agreement with the finding of [57].

3.9 Health risk index (HRI).

Consumer health risks linked to the metal contamination was determined by using HRI. The metal consumption per day was between 0.005 and 0.254, the health risk index factor ranged from 0.005 to 22 mg/kg (table 7). The health index of Pb, Cu, Cd and Fe generated from this study were found to be more than one, which suggests that the eating of the forages grown to the KIA may pose a health risk to local populations.

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Table (7): Pollution indexes for heavy metals at three sites

Heavy metals	Location	PLI	BCF soil-forage	EF	DIM	HRI
Pb	1	0.45	1.64	2.68	0.017	4.85
	2	0.63	1.21	1.98	0.018	5.14
	3	0.61	1.43	2.34	0.017	4.85
Cu	1	1.15	1.75	0.20	0.05	1.25
	2	0.90	2.46	0.28	0.05	1.25
	3	0.80	3.19	0.365	0.06	1.5
Co	1	0.16	1.32	94.4	0.005	0.12
	2	0.21	1.22	87.4	0.006	0.14
	3	0.20	1.196	85.4	0.006	0.14
Cd	1	8.63	0.54	7.6	0.019	19
	2	11.42	0.41	5.7	0.02	20
	3	12.09	0.43	6.05	0.022	22
Cr	1	0.25	1.32	5.5	0.0088	0.005
	2	0.17	2.04	8.5	0.009	0.006
	3	0.19	2.17	9.07	0.011	0.007
Zn	1	0.24	0.68	0.506	0.021	0.07
	2	0.34	0.51	0.38	0.022	0.07
	3	0.34	0.53	0.395	0.023	0.076
Ni	1	0.19	1.17	7.13	0.006	0.3
	2	0.17	1.04	6.29	0.005	0.25
	3	0.17	1.33	8.09	0.006	0.3
Fe	1	0.86	1.63	0.218	0.23	5.6
	2	0.79	1.69	0.225	0.22	5.4
	3	1.05	1.49	0.199	0.254	6.2

4. CONCLUSIONS

From the current study, results concluded that continues release of untreated effluent lead to increase the levels of heavy metals in the soil and pasture land at KIA. In addition, heavy metals are transferred apparently through the food chain levels especially in high levels in animal and human blood that possess tremendous risk to human health and ruminant animals as well as to wildlife in KIA, as all studied pollution indices confirm this fact. Moreover, the concentrations of heavy metals in animal samples were higher than the permissible level as well as in human blood reach the dangerous level. Health risk index reported in the present study was higher in Cd, Fe, Pb and Cu which indicate dangerous to consumer health. Therefore, it is recommended to manage industrial effluent appropriately to minimize the health risks at KIA.

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