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Qualitative Assessment of Pollution Indices for Heavy Metal of The Drinking Water in Kirkuk City, Northern Iraq

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Abstract: The purpose of this study is to determined and examined the qualitative status of water, with respect to the methods of heavy metal contamination indices for the drinking water quality of Kirkuk city. The 26 samples have collected in July 2015. The heavy metal concentrations were determined in the drinking water samples by using (ICP-MS) technique. Seven heavy metal concentrations including AS,Cr,Cu,Mn,Pb,Ni, and Zn which have been detected in drinking water, were measured in the selected samples of the Kirkuk city. Then by using quality indices based on heavy metals, Cd, HEI and MI, the impact on the quality of drinking water were measured and evaluated. The results show that the metal pollution of drinking water in the study area is frequently less than the threshold risk. The mean HEI (0.465) was found to be below the heavy metal pollution index value of 400. The result of the MI(0.863) elucidates that the drinking water is pure with regard to heavy metal pollution. The results show that the concentrations of 7 studied metals are little than national standards. Comparing the results of heavy metals concentration in this study with drinking water standards displays that the concentration of studied heavy metals are little than the estimated levels that were announced by the World Health Organization(WHO) and the National Standards Organization of Iraq(IQS).

Keywords: Heavy Metal, Drinking Water, Water Quality ,Kirkuk

Introduction

Drinking water is primary to humans and another life forms .It should be fresh and liberate of contaminants so as to ensure suitable health. Drinking water from different watering-place such as wells,river,lakes and tankers should be released from pollution . That confuse the major risk to human health because of contamination of these sources. Poisonous heavy metals in all environments are universal problem that is a rising resistance to humanity. There are considerably of sources of heavy metal pollution, including the coal, natural gas, paper, and chlor-alkali industries (Alloway, 1995). Toxic metals are usually present in industrial, municipal and urban runoff, which can be hurtful to humans. Water pollutants mainly consist of heavy metals, fertilizers and a lot of toxic organic compounds. Heavy metals in water occur in trace amount ,however are very toxic to the human organism (Khan et al., 2011). Numerous dangerous chemical elements if released into the environment ,it would be accumulated in the soil and sediments of water staff (Abida Begum et al., 2009). There are over 50 elements that can be classified as heavy metals, 17 of which are considered to be very toxic and comparatively attainable (Singh et al.,2004).Peculiarly, also the anions have its important role in drinking water ; results also revealed affecting the human health (Khan et al.,2014). Heavy metals in water exist only in trace concentration but are more toxic to the human body (Mohod and Dhote,2013). The heavy metals in drinking water which related most often to human poisoning are lead, iron, cadmium copper, chromium, selenium, zinc, arsenic, manganese, nickel etc .They are desired by the body in small rates , but can also be toxic in large dosage (Singh et al.,2004).

The risk of thrift safe and suitable drinking water has been considerably confirmed in international organizations like the World Health Organization. So that this organization called the 1980s as the decennium of safe drinking water (Zouli and Edris, 1998). Approbate to the statistics of the World Health Organization, more than one billion people don’t have incoming to safe drinking water about the world, so each year more than 1500000 public in the world perish because of intestinal diseases which caused a deficiency of safe drinking water, and 19% of those people are children whom are more than five years old (WHO,2006).

The famous mortal impacts of heavy metal poisoning comprised deterioration mental and central nervous function and lower energy level. They likewise cause anomaly in blood structure, severely influence necessary member like kidneys and liver. The long-range exposure of these metals perform in physical, muscular, and neurological degenerative operations that cause Alzheimer's disease, muscular dystrophy (IOSHIC, 1999).

The present study is aimed to determined and examined the water quality status, with respect to its heavy metal contamination index methods for drinking water quality of Kirkuk city .

2.Material and Methods:

2.1.Study Area:

Kirkuk city is located in the north part of Iraq and it is located between ((44° 15′00″ -44° 30′00″E)and (35° 19′00″-35° 32′00″ N)) (figure 1) . Khassa is Fragile River flux from northeast to southwest across the central of Kirkuk city. The study area is characterized by arid to semi arid climate. Lasser Zab is the major river that provides the main water source to Kirkuk province. The length of Lesser river is 400 km, and its catchment area is about 22,250 km^2 (Heshmati, 2009). Generally, this area consists of industrial, domestic, agricultural and oil fields places. Oil is the major source of its economic activities.

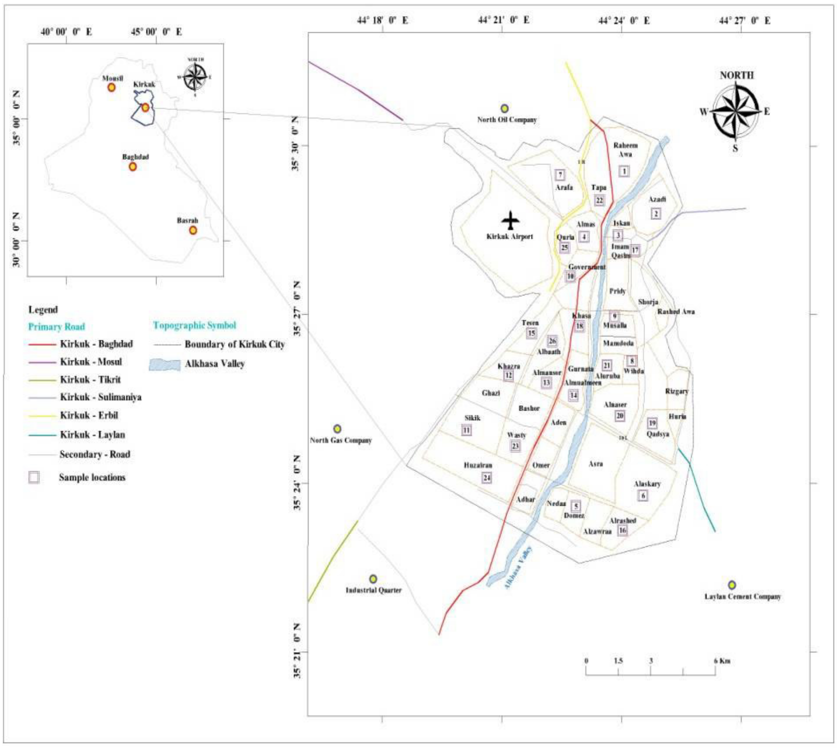

Figure1.Map of Iraq showing the sample location in Kirkuk city.

2.2.Sample Collection

Twenty six samples were collected in July 2015 at different locations in the study area. Drinking water specimen were collected in 1 liter capacity plastic bottles. Before sampling, the bottles were washed with cleaner directed by tap water and lastly various times swill with distilled water. The source for all water samples was tap water provided by water directorate of Kirkuk . The water at the sample locations were allowed to flow for several time then the bottles were swill thrice with this water and 1 liter was possessed as sample from each source of water. The samples were properly labeled. These samples were air emphasized and stored in a refrigerator to the perfect analyses were carried out.

2.3.Experimental Analysis

The physico-chemical characteristics such as (pH), electrical conductivity (EC) and temperature (C°) in drinking water samples were analyzed on pH/EC meter type (Eutech Instrument/ PCD650 / Cyber scan series 600) .All the measurements of this physco-chemical parameters was carried out in College of Science in

Kirkuk University.

The content of heavy metals in the drinking water samples was achieved. In this study total seven elements (AS,Cr,Cu,Mn,Pb,Ni, and Zn) were specified individually in each water samples using ICP-MS type (Elmer Elam perken 6000)Technique. Around 500 ml of the each water sample was filtered using Whitman filter paper no.0.45. The filtrate was gathering in specimen bottle and 3% nitric acid (HNO_3) was added up to it. ICP–MS is highly sensitive and capable of determination of an extent of metals at levels below ppb.Compound of replicates, reagent blanks and reference materials introduced by the ACME Analytical laboratories in Canada supported the excellent precision and accuracy of analytical results.

3.Result and Discussion

3.1 Heavy Metals In The Drinking Water

A little quantities of heavy metals are prevalent in water, and these are normally not hurtful to our health. Indeed, several metals are fundamental to afford life. Cobalt, copper, nickel, manganese, molybdenum, selenium, and zinc are necessary at soft levels as stimulants for fermentation action. Of course existing heavy metals are dissolved in water when it comes into contact with rock or soil substances. Another reasons of metal contamination are abrasion of tube and seepage from rubbish disposal sites (Salem et al., 2000). The metals in drink water are more probable to cause chronic health influences if that they exist long after exposure to small contains of chemical contaminations or anthropogenic activities. Such as of chronic health effects involve cancer, birth disorder, deterioration of the nervous system, and loss to the immune system (USGAO, 2000). The concentration minimum, maximum average and permissible limits of individual metals are illustrated shown in Table 1**.**

Table1. The minimum, maximum and average concentration of heavy metals (ppb) in drinking water samples of the study area with permissible limits.

parameter	Min	Max	Avg.	WHO(2004)	IQS/417(2009
As	0.6	3.3	1.54	10	10
Cr	0.6	26.5	16.49	50	50
Cu	0.6	24.4	3.76	100	100
Mn	0.18	21.63	9.33	100	100
Pb	0.1	1.5	0.26	10	10
Ni	0.2	1.1	0.42	20	20
Zn	6	579	107	3000	3000

Arsenic: The concentration of As in the drinking water samples ranged from 0.6 to 3-3 PPb with the average of 1.54 PPb table 1. The permissible limit of As is given as 10 ppb is specified by WHO and IQS/417 for drinking water. Each the specimens were within the permissible limits. The high Arsenic levels were observed in Raheem Awa, Khazra and Taba areas table 2. Particularly from in process naturally in the environment, arsenic may be released in considerable amounts through volcanic activity, erosion of rocks, forest fires, and anthropogenic. Inorganic arsenic is a famous carcinogen and can cause many cancer such as skin, lungs, liver and cyst (EPA,1999).

Chromium: The concentration of Cr in the drinking water samples ranged from 0.6 to 26.5PPb with the average of 16.49PPb table 1. The permissible limit of Cr is specified as 50 PPb by IQS/417[13] and 50 ppb is specified by WHO [14] for drinking water. Each the specimens were within the permissible limits of IQS/417and WHO. The high Chromium concentrations were observed in Raheem Awa, Almas and Almansor areas table 2. Cr is toxic element for biotical systems (Pendias and Pendias, 2001) and damage to skin and lungs (Kaaber et al., 1978). Set of few large scale industrial activities such as dyes, cement, paper, rubber and tanning are mentioned to contribute Cr (Alloway, 1995).

Table 2. Parameters measured in drinking water samples at different locations area from the Kirkuk city

Sample No.	Location area	As	Cr	Cu	Mn	Pb	Ni	Zn	pH	EC (μS cm⁻)	Temp (C°)	Metal load
1. 1	Raheem Awa	3.2	25.2	5.6	8.31	0.4	0.3	105	7.35	845.96	17	148.01
2.	Azadi	1.8	18.0	6.6	4.87	0.3	0.3	28	7.41	197.66	20	59.87
3.	Iskan	1.7	14.3	3.1	6.69	0.5	0.3	34	7.35	667.89	19	60.59
4.	Almas	1.4	26.5	3.0	0.18	0.2	0.3	6	7.85	767.76	20	37.58
5.	Domes	1.8	13.4	2.2	6.71	0.4	0.3	13	7.60	264.22	19	37.81
6.	Alaskary	1.8	14.1	1.9	7.84	0.6	0.2	7	7.23	330.41	18	33.44
7.	Arafa	0.7	13.9	10.0	9.74	0.7	0.6	27	7.09	852.12	20	62.64
8.	Wihda	1.7	15.1	2.3	8.89	0. 4	0.4	33	7.74	336.11	19	61.79
9.	Musalla	1.7	14.3	2.6	10.68	0.3	0.3	35	7.38	465.21	18	64.88
10.	Government	1.5	13.1	4.3	5.68	0.8	0.3	53	7.47	325.61	19	78.68
11.	Sikik	1.4	14.1	2.8	9.35	0.6	0.3	96	7.41	487.41	21	124.55
12.	Khazra	2.8	15.5	24.4	11.12	0.3	0.7	138	7.76	652.11	22	192.82
13.	Almansor	0.7	25.7	2.0	6.18	0.4	1.1	130	7.65	645.91	20	166.08
14.	Almualmeen	0.9	14.6	1.9	6.92	0.5	0.3	78	7.44	465.11	19	103.12
15.	Tesen	1.4	19.3	0.8	21.63	0.4	0.7	9	7.11	530.44	21	53.23
16.	Alrashed	1.8	14.9	2.3	2.49	0.3	0.2	14	7.72	287.31	20	35.99
17.	Immam Qasim	1.7	14.3	1.9	5.21	0.4	0.4	19	7.61	377.34	18	42.91
18.	Khasa	0.9	13.4	2.9	2.04	0.7	0.3	20	7.36	545.91	20	40.24
19.	Qadsya	1.7	15.1	3.0	10.92	0.4	0.3	15	7.42	751.12	19	46.42
20.	Alnaser	1.6	14.8	1.8	6.64	0.5	0.3	32	7.36	436.12	20	57.64
21.	Aluruba	1.3	14.2	2.1	6.90	0.2	0.5	81.2	7.51	414.20	21	106.4
22.	Taba	2.2	14.5	1.9	6.82	0.3	0.6	10	7.61	513.19	19	36.32
23.	Wasty	1.7	13.8	1.3	0.26	0.2	0.3	42	7.33	418.20	22	59.56
24.	Huzairan	1.0	26.3	2.1	6.28	0.4	1.0	163	7.11	586.30	19	200.08
25.	Quria	1.1	13.6	2.2	6.04	0.5	0.7	54	7.04	416.12	20	78.14
26.	Albaath	0.6	10.8	0.9	1.68	0.3	0.4	51	7.41	545.11	19	65.68
Min		0.6	10.8	0.8	0.18	0.2	0.2	6	7.04	197.66	17	**33.44**
Max		3.2	26.5	24.4	21.63	0.8	1.1	163	7.85	852.12	22	**200.08**
AV.		1.54	16.26	3.68	6.92	0.42	0.44	49.74	7.44	504.80	19.6	**79.018**

Copper: The concentration of Cu in the drinking water samples ranged from 0.6 to 24.4 PPb with the average of 3.76 PPb table 1. The permissible limit of Cu is specified as 100 PPb by IQS/417 and 100 PPb is specified by WHO for drinking water. Each the specimens were within the permissible limits. The high Copper concentrations were observed in Arafa and Khazra areas table 2. Cu is primary matter to human life, however chronic exposure to pollute drinking water with copper can effect in the increase of anemia, liver and kidney injury (EPA, 1999).This illness was a product of drinking water contaminated from abrasion of water pipes made of copper and industrial wastes. Dysentery in small children may be likewise happened because of high copper exposition. The opposite health impacts caused by drinking water polluted with copper are stomach ache, disgorge, headache, sickness and dysentery (Madsen et al., 1990).

Manganese: Mn in drinking water is associated with nervous deterioration (EPA,1999). The accumulation of Mn may cause hepatic and brain inflammation (Beckman et al., 1985). The concentration of Mn in the drinking water samples ranged from 0.18to 21.63 PPb with the average of 9.33PPb table 1. The permissible limit of Mn is given as 100 PPb by IQS/417and 100 ppb is given by WHO for drinking water. The height Mn contains were recognized in samples Khazra and Tesen of the study area table 2.

Lead: The concentration of Pb in the drinking water samples ranged from 0.1 to 1.5 PPb with the average of 0.26 PPb table 1. The permissible limit of Pb is given as 10 PPb IQS/417 and 10 PPb is given by WHO for drinking water. Each the specimens were within the permissible limits of IQS/417 and WHO. The high Lead concentrations were noticed in Arafa, Government and Khasa of the study area. Patients pain from kidney failure were related to pollute drinking water especially with lead. Pb is a critical element, it is deleterious even in little quantities. Lead come in the human body in many ways such as inhaled in dust from lead dye, refuse gases from leaded gasoline and others. Height concentrations of lead in the body may cause dying or persistent deterioration to the central neural system ,kidneys, headaches and elevated blood pressure (Jennings et al .,1996).

Nickel: The concentration of Ni in the drinking water samples ranged from 0.2 to 1.1 PPb with the average of 0.42 PPb. The permissible limit of Pb is given as 20 PPb IQS/417 and 20 PPb is given by WHO for drinking water. Each the specimens were within the permissible limits of IQS/417and WHO. The high Lead concentrations were noticed in samples Khazra, Almansor, Tesen, Huzairan and Quria of the study area. Ni is utilized as alloys manufacture, nickel-plating for anticorrosion and in the industry of batteries. It is respected as a main trace metal however poisonous in considerable quantities to human health (Kaaber et al., 1978). Hair loss patients are due to pollutant drinking water and nickel may be associated with the derma toxicity in supersensitive humans (Kaaber et al., 1978 ; Ambrose et al .,1976).

Zinc: The concentration of Zn in the drinking water samples ranged from 6 to 579 PPb with the average of 107 PPb table 1.The permissible limit of Pb is given as 3000 PPb IQS/417 and 3000 PPb is given by WHO for drinking water. Each the specimens were within the permissible limits of IQS/417and WHO. The high Zinc concentrations were observed in Raheem Awa, Khazra, Almansor and Huzairan of the study area. Severe toxicity emerge from the absorption of too much amounts of zinc salts, however unawares as an emetic or dietary accessory. Fever, sickness, stomach cramps, and diarrhea will occur after a few hours of absorption (Layrargues et al., 1998).

According to the concentrations of metals such as As,Cr,Cu,Mn,Pb,Ni, , and Zn, a few the permissible limits of both WHO and IQS/417. Drinking water in study area containing low levels of these metals, and it is possibly not risk to our health.

3.2.Calculation Of Water Quality Indices

To discuss the water quality, three indices were applied individually in this study. Heavy Metal Evaluation Index (HEI), Contamination Degree (Cd) and Metal Index (MI) were studied for the water specimen of study area.

3.2.1 Heavy Metal Evaluation Index (HEI)

Heavy metal evaluation index is a method of assessing the water quality with concentrate on heavy metals in water samples (Edet et al., 2003). The water quality index classifies into three groups which involve: low heavy metals (HEI <400), moderate to heavy metals (400 <HEI <800) and high heavy metals (HEI> 800) [20] (Jennings et al .,1996). Index of HEI is calculated from the equation (1):

$$HEI = \sum_{i=1}^{n} \frac{Hi}{Hmac} \quad \text{--------(1)}$$

Hi: Measured value for the parameter, Hmac: Standard allowed value for ith parameter

The calculated index, weight and ideal values for the elements As Cr, Cu, Mn, Pb, Ni and Zn are given in Table 3.

Table 3. Standard values, ideal values and weight of heavy metals in the study area (Siegel, 2002)

Parameter	W#	S@	I*	MAC+	RV$
As	0.02	50	10	50	0.5
Cr	0.02	50	50	50	1
Cu	0.001	1000	2000	1000	3
Mn	0.02	100	500	50	5
Pb	0.66	100	10	1.5	3
Ni	0.05	20	20	20	0.3
Zn	0.0002	5000	3000	5000	5

MAC+ Maximum Admissible Concentration

W# Weightage (1/MAC)

S@ Standard permissible in ppb

I* Highest permissible concentration

RV$ Reference Value in ppb

To calculate such index, measured values of seven heavy metals such as As, Cr, Cu, Mn,Pb, , Ni and Zn have been used. Calculated amounts of this index for the samples are given in Table 4.

According to HEI, the maximum evaluated value of metals in Huzairan area(0.697) and the minimum amount is for the Albaath area (0.278) table 4. Depending on this classification for this index, the average index for samples is (0.465) .So water samples are appreciating at low heavy metals level table 5.

Table 4. HEI,Cd and MI indices of drinking water of Kirkuk city

Sample NO.	Location area	HEI	Cd	MI
1	Raheem Awa	0.696	-6.302	1.042
2	Azadi	0.474	-6.524	0.720
3	Iskan	0.416	-6.583	0.812
4	Almas	0.581	-6.418	0.714
5	Domes	0.394	-6.603	0.724
6	Alaskary	0.415	-6.583	0.888
7	Arafa	0.441	-6.557	0.998
8	Wihda	0.457	-6.541	0.809
9	Musalla	0.454	-6.545	0.758
10	Government	0.386	-6.612	0.943
11	Sikik	0.446	-6.552	1.906
12	Khazra	0.567	-6.431	0.875
13	Almansor	0.676	-6.323	1.007
14	Almualmeen	0.416	-6.582	0.814
15	Tesen	0.671	-6.327	1.150
16	Alrashed	0.377	-6.622	0.598
17	Immam Qasim	0.401	-6.597	0.716
18	Khasa	0.335	-6.664	0.815
19	Qadsya	0.470	-6.529	0.842
20	Alnaser	0.438	-6.579	0.833
21	Aluruba	0.424	-6.574	0.492
22	Taba	0.439	-6.560	0.704
23	Wasty	0.339	-6.656	1.474
24	Huzairan	0.697	-6.301	1.022
25	Quria	0.407	-6.591	0.796
26	Albaath	0.278	-.6.720	0.492
AV		0.465	-6.530	0.863
MIN		0.278	-6.720	0.492
MAX		0.697	-6.301	1.906

Table 5. Water quality classification using HEI (Jennings et al ,.1996)

HEI	Characteristics	Sampling site at Kirkuk city
HEI < 400	Low heavy metals	All sample site
400< HEI < 800	Moderate to heavy metals	
HEI > 800	High heavy metals	

3.2.2 contamination degree (Cd)

In this index, water specimens are classified by calculating the degree of contamination in water specimen (Backman et al., 1998). Contamination degree by added various parameters assuming water quality, investigates convenience of drinking water samples for municipal consuming. Contamination degree has to be calculated split up for all sample based on the surpassed parameters from standard values. Index is calculated by the equation (2):

$$Cd=\sum_{i=1}^{n} Cfi \text{ ------------(2)}$$

Cfi in this regard can be obtained from the equation (3):

$$Cfi = \frac{CAi}{CNi} - 1 \text{ ---------------(3)}$$

Cfi: Contamination factor for the ith parameter

CAi: Measured value for the ith parameter,

CNi: Standard allowed value for the ith parameter

According to Cd, the maximum degree of contamination is for the Huzairan area (-6.603) and the minimum degree of contamination has been fixed for the Albaath area (- 6.720) table 4. The index average for the area is (-6.530), which is classified as low degree of contamination class table 6.

Table 6. Water quality classification using contamination degree

Cd	Characteristic	Class	Sampling sites at Kirkuk city
Cd < 1	Low contamination	1	All sampling site
1<cd < 3	Moderate contamination	2	-----------
Cd >3	High conterminal	3	-----------

*3.2.3.*Metal Index (MI)

This index expresses the total quality of drinking water based on metal content such as heavy metal assessment index (Tamasi and Cini, 2004) and may be calculated by the equation (4):

$$MI = \sum_{i=1}^{n} \frac{Ci}{(MAC)i} \text{ ---------(4)}$$

Ci: Measured value for the i th parameter, MACi: Standard allowed value for ith parameter

Approbate to this water quality index, water samples may be divided into three groups including: potable (MI <1), on the threshold of risk of drinking (MI = 1) and non-potable (MI> 1) table 7.

Water Quality Classification using MI (Caerio et al,.2005). ***Table 7***

MI	Characteristic	Class	Sampling Sites at kirkuk city
< 0.3	Very	1	----------
0.3- 1.0	Pure	2	All sampling site except 1, 11, 13, 15 , 23. 24
1.0 – 2.2	Slightly affected	3	1 ,11, 13 ,15, 23, 24
2.0 – 4.0	Moderately	4	----------
4.0 – 6.0	Strongly affected	5	----------
>6.0	Seriously affected	6	----------

According to MI, the maximum value of metals in Sikik area (1.906) and the minimum amount is for the Aluruba area (0.492). Depending on this classification for this index, the average index for samples is (0.863) table 4, so water samples are pure classification table 7.

Both MI and HEI indices, measurement with the employ of has the same equations, however the final classification changes. For the HEI index, the major problem concerning to the high quantity defined for threshold risk (HEI = 400), which allow the low and moderate polluted samples to set with the high polluted samples. In the status of index MI, that depend on the quality of drinking water, classification considered less for a threshold risk (MI = 1).

The concentration for the As, Cr, Cu, Mn,Pb, , Ni and Zn metals with pH, temperature and electrical conductivity of the drinking water samples taken at the Kirkuk city are display in Table 2. To investigate how the distribution of the measured parameters in drinking water samples is descriptive statistical data are presented in Table 8.

Table 8 . Descriptive statistics for the drinking water sample parameters of the study area

Parameters	**Units**	**Min**	**Max**	**Mean**	**Median**	**Std. Deviation**
Temp.	C°	17	22	19.57	19.5	1.205
Ec.	(µS cm⁻)	197.66	852.12	504.80	476.31	177.11
pH	-	7.04	7.85	7.43	7.41	0.21
As	ppb	0.60	3.20	1.54	1.65	0.59
Cr	ppb	10.80	26.50	16.26	14.40	4.47
Cu	ppb	0.80	24.40	3.68	2.25	4.64
Mn	ppb	0.18	21.63	6.92	6.70	4.27
Pb	ppb	0.20	0.80	0.40	0.40	0.17
Ni	ppb	0.20	1.10	0.43	0.30	0.23
Zn	ppb	6.00	163.00	49.73	33.50	44.19

So to discuss the relationships between measured parameters, the correlation coefficient was dragged by the software SPSS-Version 22 table 9 . Based on calculations performed at the 1% level, there is a direct correlation between the heavy metals including arsenic, and copper; So that any increase or decrease in each of them cause the other two elements to be affected. The amount of chromium is directly related to the electrical conductivity.

Table 9. Correlation coefficient for the measured parameters and calculated indices

	As	**Cr**	**Cu**	**Mn**	**Pb**	**Ni**	**Zn**	**Temp**	**pH**	**Ec**	**HEI**	**MI**	**C.d**
As	1												
Cr	0.099	1											
Cu	0.420**	0.005	1										
Mn	0.185	0.034	0.197	1									
Pb	-0.265	-0.210	0.030	0.089	1								
Ni	-0.285	0.467*	0.177	0.272	-0.064	1							
Zn	0.010	0.435**	0.363	0.053	-0.004	0.597**	1						
Temp	-0.169	-0.097	0.331	0.030	-0.1330	0.243	0.155	1					
pH	0.441**	0.092	0.197	-0.312	-0.498**	-0.168	-0.043	0.055	1				
Ec	0.017	0.446**	0.293	0.166	0.114	0.294	0.274	-0.040	-0.115	1			
HEI	0.237	0.886**	0.209	0.462**	-0.152	0.593**	0.516**	-0.035	-0.032	0.478**	1		
MI	0.564**	0.835**	0.289	0.229	-0.153	0.328	0.502**	-0.187	0.097	0.442**	0.882**	1	
C.d	0.237	0.886**	0.209	0.462*	-0.152	0.593**	0.516**	-0.035	-0.032	0.478**	0.999**	.882**	1

**. Correlation is significant at the 0.01 level (2-tailed).

According to the relationship which stated before , calculated indices such as HEI, MI and Cd were also directly affected by chromium, zinc and electrical conductivity. A case study process was used for the classification of water based on heavy metal concentration (ppb) and the pH. This method was primarily sophisticated and viewed in 1992 (Ficklin et al.,1992) and then was modified in 1999 (Caboi et al ., 1999) . In this method, the metal concentration in the sample is calculated from the total amount of metal elements, in kirkuk area, it results of heavy metals including As, Cr, Cu, Mn,Pb, , Ni and Zn. The situation of all samples is shown in Figure 2. Depend on the scheme, all of samples classified as close to near neutral pH and high metal content water.

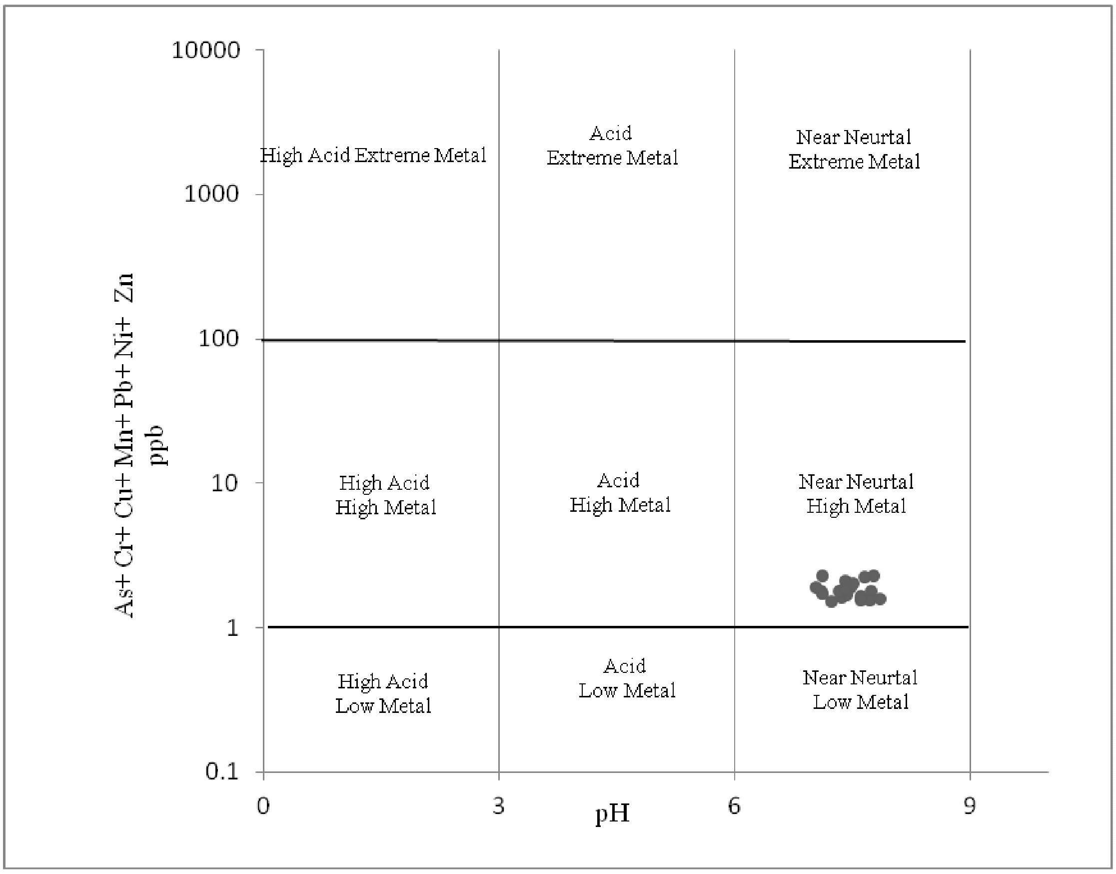

Figure 2.Diagram of drinking water classification based on the metal content and pH.

Conclusions

Twenty six samples of drinking water were collected in Kirkuk area, Iraq. From the samples analysis the following heavy metal concentration (range) were obtained (in ppb): As(0.6-3.2), Cr(13.1-26.5), Cu(0.8-24.4), Mn(0.18-21.63), Pb(0.2-0.8), Ni(0.2-1.1) and Zn(6-163.

The result acquired through study was compared with WHO(2004) and IQS/417(2001) standards. The drinking water is water safe enough to be used by humans or utilized with low hazard of direct or long term injury. The study estimate the valuation of water quality in drinking water of Kirkuk city. Heavy metal pollution index is an efficient instrument to describe the drinking water pollution. Overall HEI calculated based on the average concentration of the heavy metals was found to be 0.465 which is below the critical pollution index value of 400, indicates that the selected water samples from the drinking water are not critically contaminated with regard to heavy metals. The result of the MI was found to be 0.863 indicates that the selected drinking water is pure with regard to heavy metal pollution. According to the drinking water indices, water samples of the study area have been specified favorable for drinking water however based on the correlation coefficient, chromium has a major role in the quality of water samples. Conclusively, All heavy metal concentrations in study area is not deteriorated by heavy metal pollution and will not cause problems for human health.

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