Appraisal the Quality of Drinking Tap Water in Different Regions of Kirkuk city

Batool Kh. Mohammad[1], Kameran Sh. Husien[2], Israa Zainal[1]

[1]Assistant Lecturer. College of Science, Kirkuk University-Kirkuk, Iraq,
[2]Professor, College of Science, Kirkuk University-Kirkuk, Iraq

Abstract

This study was conducted to demonstrate the suitability of drinking tap water from different regions of Kirkuk city byanalyzing some chemical and physical properties included (temperature, pH, turbidity, electric conductivity, total soluble solids, total hardness, total suspended solids, nitrates, calcium, magnesium, chloride, sulfate, sodium and phosphate) and eight heavy metals concentration including (Cd, Cr, Cu, Fe, Zn, Ni, Mn and Mg) which have been detected in drinking water. The drinking tap water of Kirkuk city processed by the Directorate of Kirkuk's water for human consumption, all data compared with (IQS 417/2001) except for temperature. The results offered that the concentrations of 8 studied metals are little than National Standards Organization of Iraq (IQS) except for (Ni) which is found to be high (12.267mg/L) dose which not meet specifications, the results were analyzed using the analytic Jena AAS NOVAA 350. The results of chemical and physical properties compared with drinking water standards displays that the concentration of studied chemical and physical are little than the estimated levels that were announced by the National Standards Organization of Iraq(IQS) except for two analysis(turbidity and total soluble solids) were found to be highest rate(6.9NTU) and (79mg/L) respectively which does not meet specifications.

Keywords: *Heavy metals, drinking tap water, water quality.*

Introduction

Water pollution is one of the most important challenges. It has been proven that half of the world's rivers were severely polluted with decrease in the level of water. Water pollution include two sources: (point and non-point) source.[1] Point sources are effectively identifiable sources, including: oil effuse from a tanker, igniter from a factory, wastewater streaming (both municipal and manufacturing) and storm sewer discharges and affect mostly the area near it, while, non-point sources are those of different sources of origin and the number of ways in which pollution has occurred in groundwater or surface water and in the area near it like runoff from agricultural fields, urban waste…etc. Sometimes environmental pollution in one place has an influence hundred or even thousands of miles away, which is known as trans-border pollution.[2] Water pollutants may be organic pollutants (comprise of insecticides and herbicides, organo -halides and other forms of chemicals; bacteria from sewage and lives tocks farming; food processing wastes; pathogens; volatile organic compounds … etc.) and inorganic pollutants (may emerge from heavy metals which arise from acid mine drainage; silt from surface run-off, logging, slash and burning practices and land filling; fertilizers from agricultural run-off which include nitrates and phosphates... etc. and chemical waste from industrial manufacturing effluents).[1] Heavy metals are known as metallic elements that have a comparatively high density and specific gravity (about five times) compared to water,[3,4] they exist on the earth with different ratios in rocks and soil depending on their location. They are released from rocks by weathering processes to form soil

Corresponding Author:
Kameran Sh. Husien
Professor, College of Science, Kirkuk University-Kirkuk, Iraq
e-mail: kamerandalo@uokirkuk.edu.iq

and are bio-geochemically cycled to form rocks again in a natural cycle. Inorganic heavy metals as pollutants cannot degrade like organic pollutants and turn to harmless products but continue and accumulate in the soil.[5,6] Naturally water contain different concentrations from heavy metals,[7, 8] some of them are essential for the aquatic life, and others are toxic. Accumulation and distribution of metals in the aquatic system dependent on the sediment texture, mineralogical composition and physical transport.[9] Heavy metals sources in water may be from waste water without treatment, industries effluents and contamination with heavy metals ions.[10] Surface water is much exposable to contamination by heavy metals due to untreated sewage and factory waste into rivers and lakes.[11] The importance of heavy metals is getting more for their accumulation through tropic level and non-degradable nature causing a deleterious biological effect.[12, 13] The deadlier diseases like edema of eyelids, tumor, congestion of nasal mucous membranes and pharynx, stuffiness of the head and gastrointestinal, muscular, reproductive, neurological and genetic distortions caused by some of these heavy metals have been documented.[14] Subsequently, monitoring heavy metals is important for safety assessment of the environment and human health in particular.[12, 15]Also, to evaluate the status of the river water quality with respect to drinking and agricultural irrigation purposes.[16]Heavy metals are absorbed through the orally, inhalation and/ or skin. Regardless of the manner of heavy metal entry in the body, the blood circulatory system is possibly the first to be affected following exposure and adverse effects on blood coagulation can lead to associated thrombotic disease.[17] The aim of this study is to evaluate the quality of water, with respect to its heavy metal contamination index method for drinking tap water quality in different regions of Kirkuk city.

Materials and Method

The Studied Regions: Kirkuk city located in the north part of Iraq, between ((44° 15′00″ -44° 30′00″E) and (35°19′00″-35° 32′00″ N)[18] (figure 1).

Khassa is Crisp River flux from north - east to south-west across the central of Kirkuk city. The study region is characterized by arid to semi-arid climate. And the main river that requires the major water source to Kirkuk governorate is Lasser Zab. The length of Lesser river is 400 km, and its catchment area is about 22,250 km2.19 Generally, this region consists of industrial, domestic, agricultural and oil fields site. Oil is the major source of its economic efficacies.

Kirkuk City (1) Gharnata. (2) Quria. (3) Hazir. (4) Shorja . (5) Shurau. (6) Raheem Awa. (7) Arafa. (8) Khadraa. (9) Wasty.

Figure 1. Map of Iraq showing the sample region in Kirkuk city.

Samples Collection: The samples of drinking tap water were collected by following the quality sample assortment protocol and tips given inCentral Organization for Quality Control and Standardization, Council of Ministers, Republic of Iraq (IQS 417/2001) results,[20] in November 2019 from regions which is next: Gharnats, Quria, Haziran, Shorja, Shurau, Raheem Awa, Arafa, Khadraa and wasty. Drinking water sample were collected in 1 liter capacity plastic bottles. Before sampling, the special precautions were taken throughout the sampling of water within the elite places of study regions. Before the gathering of the samples, the bottles were washed with cleaner directed by tap water and different times rinse with distilled water. The water at the sample locations were allowed to rinse for several time then the bottles were rinse thrice with this water and 1 liter was taken as sample from each source of water. The samples were preserved at 4°C until used.

Sample preparation and experimental analysis

Samples were prepared by following two steps: [1] The first step including determination of physico-chemical properties (pH, electrical Conductivity (E.C°), temperature (C°) and total dissolved solid (T.D.S)) for drinking tap water. The pH of the drinking tap water samples was measured using a pH meter, which calibrated, with two standard solutions (pH 4.0 and 7.0). The conductivity, temperature and total dissolved solid of the samples was measured using a conductivity meter. The probe was calibrated using a standard solution with a known conductivity. [2] The second step including the laboratory performed which include: The analyses of eight heavy metals including (Cu, Zn, Mg, Fe, Cd, Mn, Cr and Ni) using Flame atomic absorption spectrophotometer (AA-6800 AAS coupled with GFA-EX7 graphite furnace atomizer and ASC-6100 auto sampler from Shimadzu (Koyoto, Japan), for samples. The standard solution for each tested element was prepared according to its concentration and used to calibrate the system before analyzing each water sample. The device automatically recorded focus and results of statistical analysis in Standard Deviation (SD) and Relative Standard Deviation (RSD).

Concentrations of elements were estimated using the analytic jena AAS NOVAA 350, which uses acetylene gas as fuel for both Cd, Mg, Mn, Fe, Cu, Ni, Zn, Cr respectively, and used air as a Catalyst for all elements. The Liquid spray rate 4ml/min at wavelengths was 228.8, 285.2, 279.5, 248.3, 324.8, 232, 213.9, 357.9 (nm) respectively. Also, Standard analytical chemistry method and EDTA were used to measure the Ca and total hardness, Argentometric method is used to measure the Cl and the Mg using calculation method. The phosphate was measured Vanadomolybdo phosphoric acid colorimetric method, Flam emission Photometer is used to measure the Sodium and the sulfute using Gravimetric method. For the turbidity used turbidity meter. Measurement of the TSS by gravimetric method. Finally, using Brucine method to measure nitrate.

Results and Discussion

Table (1) shows the values of the analyzed physiochemical parameters of drinking tap water from different regions in Kirkuk city.

Table (1): Physiochemical parameters of drinking tap water from different regions in Kirkuk city

Region	pH	T (C°)	EC° (µs/cm)	*TDS (mg/l)	Turbidity (NTU)	**TSS (mg/l)
Gharnata	8	20.9	388	179	5.9	69.3
Quria	7.8	20.6	386	177	6.4	73.7
Haziran	7.9	19.9	410	185	6.9	79
Shorja	7.9	20.2	386	175	6.1	71.3
Shurau	8	21.5	556	259.3	4.4	54
Raheem Awa	7.9	20.4	411	188	5.6	68.7
Arafa	7.7	24.2	397	195.3	4.8	58
Khadraa	8.1	20.6	410	188	6.5	68.3
Wasty	8	20.2	407	181.3	5.8	75

*TDS :total Dissolved solids, ** TSS :total Suspended Solids.

The obtained pH values ranged from 7.7 to 8.1 with an overall mean of (7.9), the permissible limit of pH is given as (6.5-8.5) by IQS/417. The highest value found in Khadraa region and the lowest in Arafa region of Kirkuk city, note that it conform to the specification, indicating that the during tap water in Kirkuk city is alkaline (pH >7). Furthermore, there are no remarkable variations in sampling sites, and thus, it can be concluded that the water treatment and purification method had only a small effect on the hydronium ion concentration.[21] The temperature results indicated that the highest temperature of drinking tap water were found in the Arafa region while the lowest in the Haziran region, the temperature ranges between (19.9 - 24.2C^{o}) with an overall mean of (20.9C^{o}), the water temperature changes with the change in weather. Measurement is necessary because it affects various water properties such as (viscosity, density, solubility) of chemicals and bacteriological activity. The temperature affects chlorine effectiveness in water sterilization where chlorine is more effective in sanitizing water with increasing water temperature,[22] as cleared in the table (1). The E.C^{o} of the regions to drinking tap water of Kirkuk city was measured and found that the highest value in Shurau region while the lowest value in Shorja and Quria regions, where the E.C^{o} ranged between (386 – 556) µs/cm with an overall mean of (416) µs/cm as presents in table (1), the permissible limit of E.C^{o} is given as 1000 µg/cm by IQS/417, note that it conform to the specifications. There is a relationship between turbidity and water quality, also a between turbidity and bacterial content in water, the turbidity lower the chlorine's effectiveness in sanitizing the water and therefore water need more chlorine to eliminate the bacteria and pathogens.[23] The analysis showed that the rang value of turbidity within the range of (4.4-6.9) NTU with an overall mean of (5.65) NTU as in presents table (1), the regions of drinking tap water Kirkuk city results found that the highest value in Haziran region and the lowest value in Shurau region. the permissible limit of turbidity is given as 5 NTU by IQS/417 and found that it does not comply with the specifications. The T.S.S consists of organic and clay materials, and contains some microorganisms such as algae and bacteria. In the current study the values of T.S.S ranged from (54 to 79) mg/L and TSS an overall mean of (68) mg/L of the regions to drinking tap water of Kirkuk city and found the highest value in Haziran region and the lowest value in Shurau region as cleared in table (1). The permissible limit of T.S.S is given as 0mg/L by IQS/417, and it does not comply with the specifications. The T.D.S of the regions to drinking tap water of Kirkuk city was measured and found that the highest value in Shurau region while the lowest value in Shorja and Quria regions, where the T.D.S ranged between (175 – 259.3) mg/L with an overall mean of (191) mg/L as presents in table (1).

Table (2): Chemical analysis of drinking water in the city of Kirkuk:

Region	Po_4^{-3} (mg/l)	Total Hardness (mg/l)	Ca^{+2} (mg/l)	Mg^{+2} (mg/l)	Cl^- (mg/l)	Na^+ (mg/l)	So^{-2}_4 (mg/l)	NO_3^- (mg/l)
Granda	1.98	178	37.3	21.3	16.7	9.3	38	7.076
Quria	2.383	182	38.7	20.8	16.7	9.33	38.1	7.64
Haziran	1.7	182	38	21.13	16.6	9.5	36.7	7.25
Shorja	1.45	182	38.7	20.9	16	9.3	36	7.125
Shurau	1.323	195	47.3	18.63	23.3	14.7	46	7.162
Raheem Awa	1.625	178	36	21.5	13.3	9.3	33.3	7.458
Arafa	1.348	182	38.7	20.8	16	9.7	35.3	7.69
Khadraa	1.953	183.7	37.7	21.83	17.3	10.7	34	7.209
Wasty	1.653	185	38.7	21.6	17.3	10.3	34	6.758

The PO_4^{-3} of drinking tap water regions of Kirkuk city, found to be higher value in Quria region and lower rate in Shurau region, where the PO_4^-ranges between (1.323 – 2.383) mg/L with an overall mean of (1.7) mg/L as in table (2). The permissible limit of PO_4^{-3} is given as 3 mg/L by IQS/417, it conform to the specifications. The total hardness and Ca^{+2} of the above regions drinking tap water of Kirkuk city was measured and found that the highest value in Shurau region and the lowest value in Raheem Awa region, where the total hardness is between (178 – 195) mg/L with an overall mean of (183) mg/L, Ca^{+2} is ranges between (36 – 47.3) mg/L with an overall mean of (39) mg/L as clear in table (2), the permissible limit of total hardness is given as 500 mg/L and Ca^{+2} is concentration equal to 50mg/L by IQS/417 and it conform to the specifications. The measuring Mg^{+2} of drinking tap water in different regions of Kirkuk city cleared that higher value in Khadeaa region and the lower value in Shurau. The Mg^{+2} ranges between (18.63 –21.83) mg/L with an overall mean of (20.94) mg/L as in table (2), the permissible limit of Mg^{+2} is given as 50 mg/L by IQS/417, note that it conform to the specifications. Measuring the Na^{+} and Cl^{-} concentration of the drinking tap water of Kirkuk city, the results indicated that the Higher value were in shurau region and the lower value in Raheem Awa region, where the Na^{+} ranges between (9.3 - 14.7) mg/L with an overall mean of (10) mg/L, and Cl^{-} ranges between (13.3 – 23.3) mg/L with an overall mean of (17) mg/L as in table (2), the permissible limit of Na^{+} is 200 mg/L and Cl^{-} as 250mg/L by IQS/417, they conform to the specifications. The SO_4^{-2} concentration of the drinking tap water regions of Kirkuk city found that the higher value in Shurau region and the lower value in Raheem Awa region, where the SO_4^{-2} ranges between (33.3 – 46) mg/L with an overall mean of (37) mg/L as in table (2), the permissible limit of SO_4^{-2} is given as (250) mg/L by IQS/417 and it conform to the specifications . The NO^{3-} concentration was measured of the drinking tap water regions of Kirkuk city and found that the higher value in Quria region and the lower value in Wasty region, where the NO_3^{-} ranges between (6.758 – 7.69) mg/L with an overall mean of (7.2) mg/L as in a table (2), the permissible limit of NO_3^{-} is given as (50) mg/L by IQS/417, it conform to the specifications. The concentration of Cu in the drinking tap water samples ranges from (0 - 0.526) mg/L with the average of (0.2012) mg/L as in a table(3). The permissible limit of Cu is specified as 1 mg/L by IQS/417, it conform to the specifications.[24]

Table (3): The values of (Cu, Ni, Zn) by Flame atomic absorption spectrometer of drinking tap water in different regions of Kirkuk city:

Region	Copper			Nickel			Zinc		
	mg/l	SD	RSD[%]	mg/l	SD	RSD[%]	mg/l	SD	RSD[%]
Gharnda	0.3505	0.02583	7.369	7.235667	1.3223	63.854	N.D	N.D	N.D
Quria	0.525867	0.105645	17.44033	8.993	1.15415	11.397	N.D	N.D	N.D
Haziran	0.215	0.10116	29.92667	8.657	1.149	15.525	N.D	N.D	N.D
Shorja	0.08215	0.2549	310.3	12.26733	1.321433	9.491	N.D	N.D	N.D
Shurau	0.08215	0.2142	327	6.792	1.792	26.57	N.D	N.D	N.D
Raheem Awa	0.0655	0.1492	75.65	4.718	2.03135	41.695	N.D	N.D	N.D
Arafa	0.08715	0.161935	201.085	3.901	0.583733	14.02333	N.D	N.D	N.D
Khadraa	N.D	N.D	N.D	5.6755	0.9523	14.8515	N.D	N.D	N.D
Wasty	N.D	N.D	N.D	0.9442	0.7812	133.075	N.D	N.D	N.D

The concentration of Ni in the drinking tap water samples ranges from (0.9442– 12.267) mg/L with the average of (6.5759) mg/L as in a table (3). The permissible limit of Ni is given as 0.02 mg/L IQS/417 for drinking tap water, all samples did not meet the permissible limits of IQS/417. The high Ni concentration was sound in samples of Shorja, Huzairan and Quria regions and the lower region in Wasty region.[25] The concentration of Zn of the different regions drinking tap water of Kirkuk city, did not reach the percentage of Kirkuk city regions as in table (3). The permissible limit of Zn is given as 3 mg/L IQS/417 for drinking tap water. Each specimen was within the permissible limits of IQS/417.[26] The concentration of Fe in the drinking tap water samples ranged from (0- 0.0205) mg/L with the average of (0.01907 mg/L) mg/L as in a table (4). The permissible limit of Fe is given as 0.3 mg/L IQS/417 for drinking water. Each the specimens were within the permissible limits of IQS/417. The high Fe concentrations were noticed in Gharntaa and Quria samples of the study regions but there are not in Wasty, Khadraa, Arafa, Raheem Awa, Shurau and shorja of the study regions.

Table (4): Measurement of (Cd, Mn, Fe) by Flame atomic absorption spectrometer of drinking

Region	Iron			Cadmium			Manganese		
	mg/l	SD	RSD[%]	mg/l	SD	RSD[%]	mg/l	SD	RSD[%]
Gharnata	0.020503	0.000794	4.364667	N.D	N.D	N.D	0.00299	0.000033	1.162333
Quria	0.018338	0.003821	48.9585	N.D	N.D	N.D	0.003707	0.0000497	1.474667
Haziran	0.01837	0.01378	75.04	N.D	N.D	N.D	0.004415	0.0000477	1.081667
Shorja	N.D	N.D	N.D	N.D	N.D	N.D	0.00464	0.0000213	0.433667
Shurau	N.D	N.D	N.D	N.D	N.D	N.D	0.005815	0.000055	0.968
Raheem Awa	N.D	N.D	N.D	N.D	N.D	N.D	0.005989	0.0001017	1.678
Arafa	N.D	N.D	N.D	N.D	N.D	N.D	0.006336	0.000037	0.616667
Khadraa	N.D	N.D	N.D	N.D	N.D	N.D	0.007591	0.0000297	0.390333
Wasty	N.D	N.D	N.D	N.D	N.D	N.D	0.007587	0.0000577	0.767667

The concentration of Mn in the drinking tap water samples ranges from (0.00299- 0.007591) mg/L with the average of (0.005452) mg/L as in a table (4). The permissible limit of Mn is given as 0.1 mg/L IQS/417 for drinking water. Each the specimens were within the permissible limits of IQS/417. The higher Mg concentrations were noticed in samples khadraa and Wasty of the study regions and the lower rate in Gharnata of the study region. The levels of Cdpresent in drinking tap water of Kirkuk city appeared that did not get a percentage in the different regions of Kirkuk city as in a table (4). The permissible limit of Cd is given as 0.003 mg/L IQS/417for drinking tap water. Each the specimens were within the permissible limits of IQS/417. The Cr levels of the drinking tap water regions of Kirkuk city did not get a percentage in the regions of Kirkuk city as in a table (5). The permissible limit of Cr is given as 0.05 mg/L IQS/417 for drinking water. Each the specimens were within the permissible limits of IQS/417.[27]

Table (5): Mg and Cr concentration by Flame atomic absorption spectrometer of drinking tap water of Kirkuk city.

Region	Magnesium			Chromium		
	mg/l	SD	RSD[%]	Mg/l	SD	RSD[%]
Gharnata	0.450333	0.003441	0.770667	N.D	N.D	N.D
Quria	0.380933	0.003969	1.042	N.D	N.D	N.D
Haziran	0.5796	0.003767	0.745333	N.D	N.D	N.D
Shorja	0.450967	0.003913	0.803	N.D	N.D	N.D
Shurau	1.187667	0.016068	1.777	N.D	N.D	N.D
Raheem Awa	0.628867	0.002311	0.392333	N.D	N.D	N.D
Arafa	0.622	0.010647	1.579333	N.D	N.D	N.D
Khadraa	0.635067	0.006713	0.849	N.D	N.D	N.D
Wasty	0.3641	0.001564	0.431333	N.D	N.D	N.D

The level of Mg of the drinking tap water samples ranges from (0.3641- 1.187667) mg/L with the average of (0.5888) mg/L as in a table (5). The permissible limit of Mg is given as 50 mg/L IQS/417 for drinking water. Each the specimens were within the permissible limits of IQS/417. The higher Mn levels were noticed in samples Shurau and Khadraa of the study regions and the lower value in Wasty of the study region. Likewise, Mg, Mg^{+2} was measured in search and these was a large difference between atom-shaped Mg and ion-shaped magnesium, the reason for this relates to some of the interference that has been challenged due to the presence of some element ions that lead to interference with the magnesium ion.[28]

Table (6) cleared the water quality characteristics according to Iraqi specifications, (minimum, maximum and average) concentration of heavy metals, chemical and physical properties of drinking tap water sample of the studied regions.

Table (6): Classifying water quality characteristics of drinking tap water sample of the studied regions.

Parameters	Unit	(IQS 417/2001)	Min	Max	Average
pH	-	6.5-8.5	7.7	8.1	7.9
TDS	mg/l	1000	175	259.3	191.988
TSS	mg/l	0	54	79	68.588
NO_3^{-2}	mg/l	50	6.758	7.69	7.26311
Mg^{+2}	mg/l	50	18.63	21.83	20.9433
Ca^{+2}	mg/l	50	36	47.3	41.65
SO_4^{-2}	mg/l	250	33.3	46	36.822
Cl^-	mg/l	250	13.3	23.3	17.022
Na^+	mg/l	200	9.3	14.7	10.236
PO_4^{-3}	mg/l	3	1.323	2.383	1.712
Cd	mg/l	0.003	N.D	N.D	N.D
Cr	mg/l	0.05	N.D	N.D	N.D
Cu	mg/l	1	0.0655	0.5258	0.2011
Fe	mg/l	0.3	0.01833	0.0205	0.01907
Zn	mg/l	3	N.D	N.D	N.D
Ni	mg/l	0.02	0.9442	12.2673	6.5759
Mn	mg/l	0.1	0.0029	0.0076	0.0055
Mg	mg/l	50	0.3641	1.1876	0.5888
E.C^{o}	mg/l	1000	386	556	416.77
Total hardness	mg/l	500	178	195	183.1
Turbidity	NTU	5	4.4	6.9	5.65

Conclusions

Twenty-seven samples of drinking water were collected in Kirkuk region. From the samples analysis the following heavy metal, chemical and physical properties (range) were obtained (in mg/L): pH(19.9-24.2), T.D.S(175-259.3), T.S.S(54-79), No_3^{-2} (6.758-7.69), Mg^{+2} (18.63-21.83), Ca^{+2} (36-47.3), So_4^{-2} (33.3-46), Cl^- (13.3-23.3), Na^+ (9.3-14.7), Po_4^{-3} (1.323-2.383), Cd (0), Cu(0.0655-0.5258), Cr(0), Fe(0.01833-0.0205), Zn(0), Ni(0.9442-12.2673), Mn (0.0029-0.0076), Mg (0.3641-1.1876), E.C^{o} (386-556), total hardness (178-195), Turbidity (4.4-6.9NTU) and temperature (19.9-24.2C^{o}). The results showed that the concentrations of 8 studied metals are little than (IQS) except for (Ni) which is found to be high (12.267mg/L) dose which not meet specifications, the mean concentrations of the metals were observed in the order: Ni>Mg>Cu>Fe>Mn>Zn>Cd>Cr. The results of chemical and physical properties compared with drinking water standards displays that the concentration of studied chemical and physical are little than the estimated levels that were announced by the (IQS) except for two analysis(Turbidity and total soluble solids) were found to be highest rate(6.9NTU) and (79mg/L) respectively which does not meet specifications. But a tap water and equipped by the Directorate of Water Kirkuk has been found to occur large variations between regions in the physical, chemical characteristics and heavy metal despite being processed from the same source was due to the poor quality of networks, processing and leaks in pipelines causing water pollution.

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