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A comprehensive analytical study of water quality in Al-Khalidiya district in Anbar governorate, Iraq

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A comprehensive analytical study of water quality in Al-Khalidiya district in Anbar governorate, Iraq

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Abstract
The study includes physical, chemical and bacteriological measurements of raw and drinking water in Al-Khalidiyah district in Al-Anbar governorate at several areas which are (Al-Khalidiya Central, Al-Sadiqiya, Al-Madiq, Al-Shuhada neighborhood). The collection of samples began in February until April 2019. This study includes the conduct of physical measurements of (temperature, electrical conductivity, turbidity, suspended solids and dissolved solids) and chemical measurements of (pH and positive ions (calcium magnesium, sodium and potassium), negative ions (sulfates, chlorides, nitrates, alkalinity and total hardness) and bacteriological measurements (M\Plate count1) and (E. Coli).
The results showed that there are a variation in the values from the Iraqi and international standard limits, as there was an increase in electrical conductivity and the concentration of magnesium and sulfate. The rest of the properties did not exceed the limits of Iraqi and international standard. The results were also analyzed statistically using the SPSS statistical program. Direct and inverse correlations between the variables (water properties) were found, as well as the correlation between physical and chemical measurements of different water properties.

Keywords: drinking water, Al-Khalidiyah district, physical measurements, chemical measurements, SPSS statistical program.

Introduction

The water resources of any country and at any time are the basis for making life in all its forms and as a guarantee of its longevity(1). Pure and treated water have become an urgent and necessary need not only for drinking water and household uses, but they also have become necessary for the cultural development of any region or country.
Every industry or power plant or plant, or any project of any kind, needs clean or treated water, depending on the type and need of each case(2).
Water is one of the basic natural sources that a person needs daily and which is prepared through water purification plants. Therefore, it is necessary that the drinking water is free from contaminants and does not cause harm such as diseases or pain, in addition to have good taste and free of odors(3). It has been scientifically proven that if waste water is not treated well it causes serious diseases for humans, especially if it leaks into drinking water because the waste water contains large numbers of microorganisms such as bacteria, viruses and parasites that cause many diseases such as cholera, typhoid and polio(3).
The damage may sometimes come from impurities that are invisible and tangible, so local and international standards have been set for limits of impurities that must be available in drinking water. The world health organization has confirmed that 80% of human infections in developing countries are caused by water pollution(4).
Temperature is one of the important properties that can affect various water properties, such as viscosity, density, solubility of chemicals and bacteriological activity(5).

The traditional methods of water purification do not eliminate industrial pollutants such as hydrocarbons, inorganic pollutants, pesticides, and various chemical compounds. In addition, the Chloride used to sterilize water may interact with hydrocarbons, forming carcinogenic Chloride hydrocarbons[6].

Study area

Khalidiya is one of the cities of the Anbar governorate located in the middle of Iraq. Away from the capital, Baghdad, about 80 kilometers, located between Ramadi and Fallujah[7], figure 1 shows the study area. The Khalidiya central water project is considered one of the best important projects in Khalidiya district, as it feeds most of the Khalidiya areas with potable water during the day, and the water and bacteriological materials produced from this project are considered to be the finest types of water in terms of its characteristics and free of impurities. In the past, water quality was judged by its physical properties such as taste, smell, and color only, but the development of chemical, biological, and medical sciences led to the existence of methods to measure water quality and determine its impact on human health and living organisms[8]. Table 1 shows codes and sample sites that were used for the purpose of collecting samples.

Figure 1. A map showing the study area

Table 1. Sample codes and locations that were used for the purpose of collecting samples.

№	Sample	Type of sample	Symbol
1	Khalidiya water system	Tap water	K1
2		Middle of the river	K2
3	Siddiquia water system	Tap water	Sd1
4		Middle of the river	Sd2
5	Almudiq water system	Tap water	M1
6		Middle of the river	M2
7	Shuhada neighborhood water system	Tap water	Sh1
8		Middle of the river	Sh2

Literature Review

Multiple studies of the quality of the Euphrates river have shown that the values of electrical conductivity, total dissolved materials, aluminum and nitrite have increased and exceeded the permissible standard limits[9]. In another study, it was found that the concentration of phosphate, aluminum and nitrate ions in the river water was within the standard limits[10].

Another study also showed that there is a difference between the water quality in the areas of the right side of the Euphrates river from the areas of the left side, which is characterized by a rocky nature, while the areas of the left side are characterized by a sandy nature[11].

Studies also showed that there is a variation in the values from one region to another, but the water in general was suitable for agricultural and irrigation purposes, but it cannot be used for drinking except after treatment in all study areas[12].

Studies have shown an increase in the values of most physical and chemical properties in number of locations, and these values may exceed the maximum limits permitted globally which is related to the impact of military operations and the destruction in infrastructure such as the demolition of bridges, buildings, and rubble and wastes thrown into the river[13].

A study of water quality in the (Great Ramadi Water project) showed that pH, basic, total hardness, calcium ion concentration, magnesium ion concentration, chloride ion concentration, total salt concentration TDS, suspended solids concentration TSS, sodium ion concentration, potassium ion concentration and nitrate concentration were within the Iraqi specifications except for the sulfate concentration, turbidity, and electrical conductivity values which were higher than the Iraqi specifications[14].

Another study revealed that there is a variation in the values from the Iraqi and international standard limits, where there was an increase in electrical conductivity and the concentration of magnesium and sulfate, while the rest of the properties did not exceed the Iraqi and international standard values[15].

Aims of the study

The study aims to achieve the following goals:

1. Conducting a comprehensive analytical study on the water quality in the district of Khalidiyah. Samples are collected from the river and housing unit in all study areas for the conducting of physical laboratory tests such as (turbidity, electrical conductivity, suspended solids and dissolved solids) and chemical tests such as (pH, total hardness, calcium ion, magnesium ion, sodium ion, potassium ion, sulfate, chloride ion, and alkalinity) and compare them with the results of the laboratory tests obtained from Khalidiya water project as well as with the Iraqi and international standards.
2. Evaluating the efficiency of Khalidiya water station's work in filtering raw water and providing drinking water to citizens.
3. Study the possible environmental pollution of the river in the study area and make a comparison between the water quality in the region and study the changes taking place in the water quality.

Experimental part

1- Physical Measurements

Temperature (T):

The Temperature is measured on-site by the enclosed mercury thermometer.

Turbidity:

The turbidity is measured using a turbidity meter calibrated using standard solutions of suspended formazine polymers attached to the device. The result is calculated using the nephelometric turbidity unit (NTU)[16].

Total suspended solids TSS:

The test is conducted according to APHA method[17].

Total dissolved solid TDS:

The test is conducted according to APHA method[17].

Conductivity:

Electrical conductivity measuring device is used for the measurements after calibrating the device using potassium chloride solution (concentration 0.1N).

2- Chemical Measurements:

pH:

pH is measured using pH-meter device after calibrating the device using standard regulator solutions (4, 7 and 9).

Total Hardness:

It is measured following the world health organization method[18].

Calcium Ca^{+2} and Magnesium Mg^{+2}:

Method EDTA is used for the measurements and calibration[19].

Total alkalinity measurement (as $CaCO_3$):

It is measured following the world health organization method[17].

Determination of chloride Cl^-:

The test was conducted according to Moore method[20].

Sulphates SO_4^{-2}:

Sulphates concentration is determined according to ASTM D516-80 method[21].

Sodium Na^+ and potassium K^+:

They are determined using flame photometer method[6].

Nitrates NO_3^-:

Nitrates concentration is determined according to ASTM D516-80 standard method[21].

3- Bacteriological factors include (E. Coli and Coliform group):

They are measured following the procedure mentioned in reference number[22].

Results and Discussion

Samples were collected from 4 regions. Each region has two different samples (drink and river). Physical tests (temperature, conductivity, turbidity, total dissolved sold, total suspended sold) and chemical tests (pH, total hardness, alkalinity, positive and negative ions (Na^+, Mg^{+2}, K^+, Ca^{+2}, SO_4^{-2}, Cl^-) have been conducted. The results values were compared with the laboratory results accomplished in Khalidiya water project at the mean time compared with the Iraqi and international standards to determine their suitability for drinking.

1- Physical properties

a) Temperature

The temperature values ranged between (16-18) ^{o}C with an average of (17.5 ^{o}C) as shown in figure 2. When comparing this value with the standard value of 25 ^{o}C [(23)], it is noted that less than the standard limit. This indicates that there is no thermal pollutant in that water. Likewise, when comparing the laboratory results which were ranged between (15.4-18 ^{o}C) with an average of (17.78 ^{o}C) with standard limits, it can be noted that it is within the limit. In other words, the results are within the standard limits.

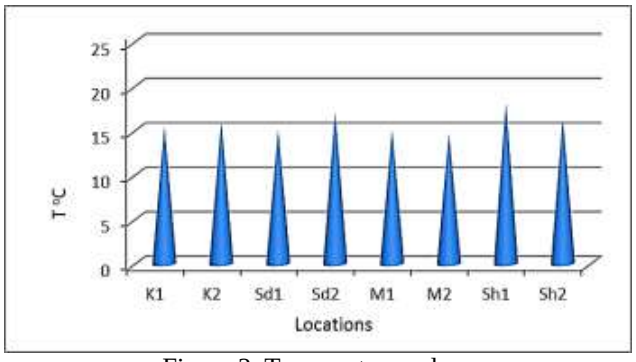

Figure 2. Temperature values

b) Electrical conductivity

The values of electrical conductivity are ranged between (1269-1370) microsiemens\cm with an average of 1317.88 microsiemens\cm. As shown in figure 3, it can be noted that the values are higher than the standard value of 1000 microsiemens\cm according to Iraqi standard[(24)] (I.S. 1996), because the raw water may contains light concentrations of ionized mineral salts which can increase the electrical conductivity[(25)]. That is, the increase in electrical conductivity is due to the high level of salinity caused by mineral pollutants. On the other hand, when comparing the laboratory result, which ranged between (1230-1424) microsiemens\cm at an average of 1344 microsiemens\cm), it can be seen that the results is higher than the standard limit.

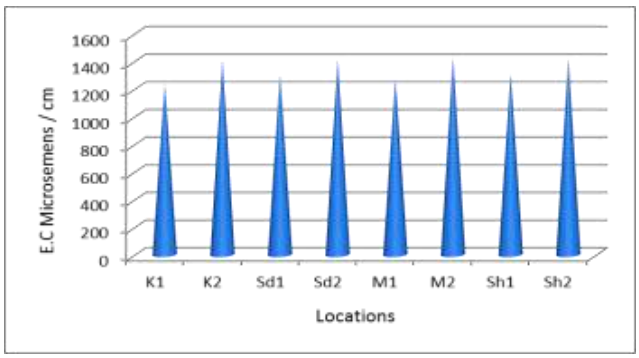

Figure 3. Electrical conductivity values

c) Total suspended solids TSS

The values of suspended solids ranged between (4-8) mg/l with an average of 12.75 mg/l, meaning that they did not exceed the standard value of 1000 mg/l in according to (I.S. 1996) [24] as shown in the figure 4. At the meantime, the values of laboratory tests which ranged between (8-24 mg/l) at an average of 18 mg/l, were also within the standard limits.

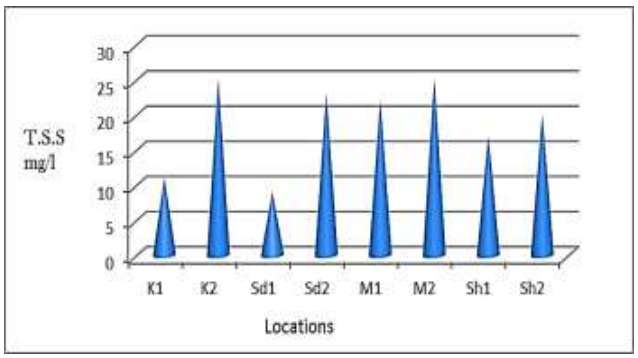

Figure 4. The total suspended solids values

d) Total dissolved solids TDS

The values of the dissolved solids ranged between (810-884) mg/l at a rate of 856.88 mg/l, meaning that they did not exceed the standard value of 1000 mg/l in all study areas as shown in figure 5. As for the results of laboratory tests, which ranged between (977-1050) mg/l at a rate of 1021 mg/l, the result was higher than the standard limits.

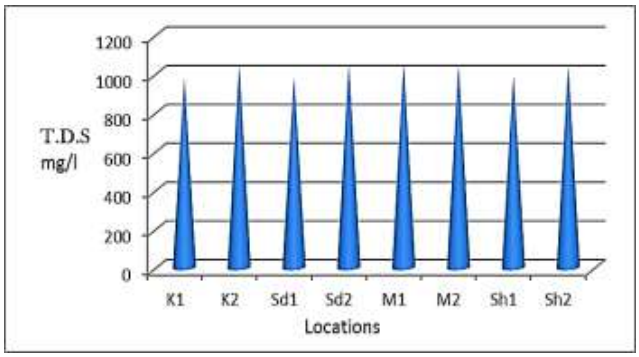

Figure 5. Values for dissolved solids

e) Turbidity

Turbidity values ranged between (1.6-5.6) NTU at a rate of 3.86 NTU, that is, they did not exceed the standard value of 5 NTU in all study areas according to the Iraqi specification I.S. 1996[24] as shown in figure 6. Likewise, when comparing the laboratory result that ranged between (2.4-4.3) NTU at a rate of 2.94 NTU, it can be recognized that it did not exceed the mentioned standard value. Table 2 shows the extent and rate of physical properties and their comparison with standard specifications and laboratory results.

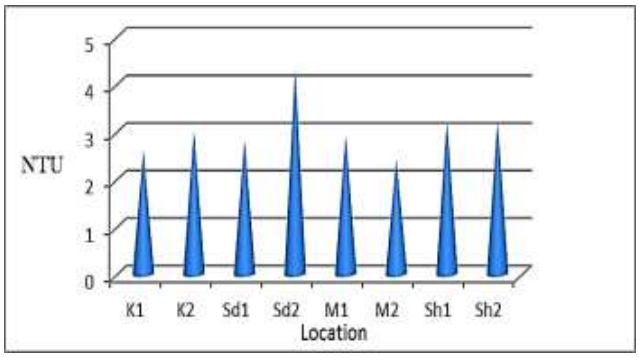

Figure 6. Turbidity values

Table 2. Range and rate of physical properties and their comparison with standard specifications and laboratory results

Sample	Results of Khalidiya water directorate tests					Laboratory tests				
	T	E.C	TDS	TSS	Turbidity	T	E.C	TDS	TSS	Turbidity
K1	18	1315	878	8	2.3	15.4	1230	977	10	2.6
K2	18	1290	872	18	5.6	16	1402	1043	24	3
Sd1	18	1322	882	8	2.3	15	1296	980	8	2.8
Sd2	18	1294	848	18	5.5	17	1410	1047	22	4.3
M1	16	1370	818	4	1.6	15	1269	1050	21	2.9
M2	16	1357	810	16	5.2	14.6	1424	1042	24	2.4
Sh1	18	1326	884	10	2.5	18	1306	991	16	3.2
Sh2	18	1269	863	20	5.9	16.3	1416	1041	19	3.2
Range	16-18	1269-1370	810-884	4-20	1.6 – 5.9	15.4 – 18	1230-1424	977 - 1050	8 - 24	2.4 – 4.3
Average	17.5	1317.88	856.88	12.75	3.86	17.78	1344	1021	18	2.94
I.S.	25	1000	1000	1000	5	25	1000	1000	1000	5

2- Chemical properties

a) pH

The pH values in water are ranged between (7.7-8.3) with an average of 8.05. that means that they are within the standard limits of (6.5-8.5) according to the Iraqi specifications I.S. 1996[24] as shown in figure 7. Also, when comparing the laboratory result, which ranged between (7.63-8.2) at a rate of 7.85, it is noted that it did not exceed the standard limit too.

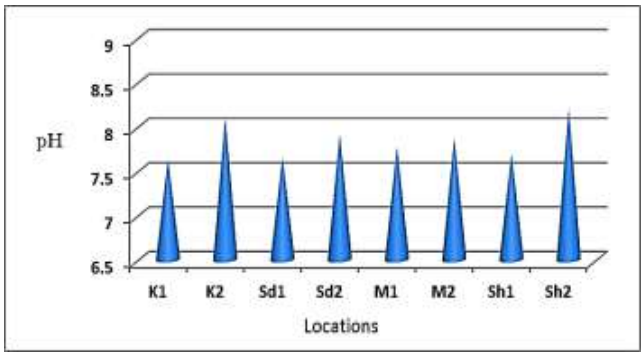

Figure 7. The pH values

b) Total hardness

The hardness values are ranged between (435-474) mg/l at a rate of 398 mg/l, meaning that it did not exceed the standard value of 500 mg/l according to the Iraqi specifications I.S. 1996 [24] and as shown in figure 8. When comparing the results with (Todd) classification system[26] as shown in table 3, it can be observed that the water quality is very heavy. Likewise, when comparing the laboratory result whose values ranged between (460-539) mg/l at a rate of 496 mg/l with the standard limit, it is noted that they did not exceed the standard limit. As for its comparison with the (Todd) method, it is noted that the water quality is very heavy as well.

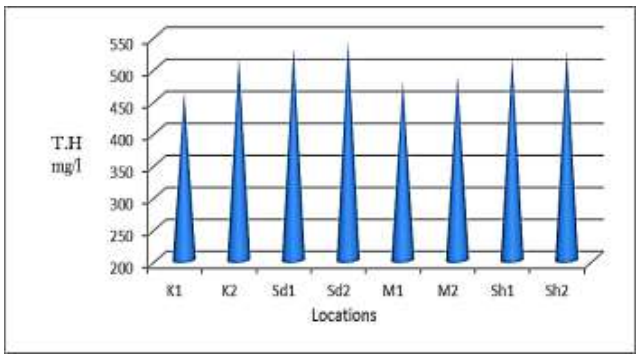

Figure 8. Total hardness values

Table 3. Classification of water by total hardness values

Water class	Total hardness, mg\l
Dulcet	75 - 0
Medium heavy	150 - 75
Heavy	300 - 150
Very heavy	<300

c) Alkalinity

The alkalinity values are ranged between (94-102) mg/l with an average of 109.2 mg/l, meaning that they were within the range of standard limits (125-200) mg/l as shown in figure 9. When comparing the laboratory results, which were ranged between (130.1-174.6) mg/l with an average of 157.8 mg/l, it can be observed that it did not exceed the standard value as well.

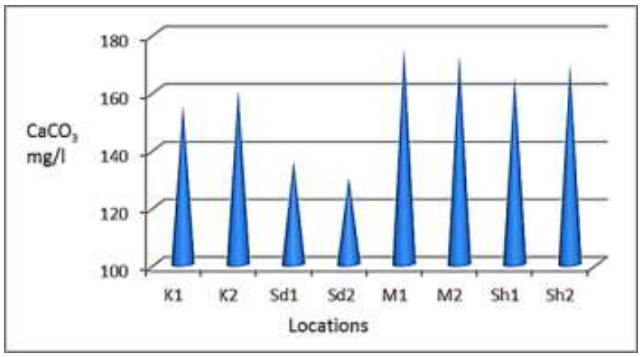

Figure 9. alkalinity values

d) Calcium

The concentrations of calcium ion are ranged between (113-117) mg/l with an average of 115 mg/l. the results revealed that the calcium concentration is less than the limit of the standard specifications of 200 mg/l[24] as shown in figure 10. When comparing the laboratory results that ranged between (40-120) mg/l with an average of 86 mg/l, it can be found that calcium concentration is within the standard limit.

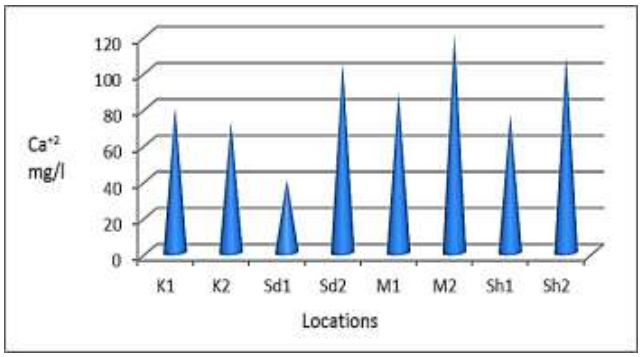

Figure 10. Calcium ion concentration values

e) Magnesium

The values of magnesium ion are ranged between (35-49) mg/l with an average of 39.88 mg/l. The results show that there is an increase in magnesium concentration compared to standard limits of 50 mg/l as shown in figure 11. It can be seen that the laboratory result that ranged between (33-55) mg/l with an average of 40 mg/l was within the standard limit too.

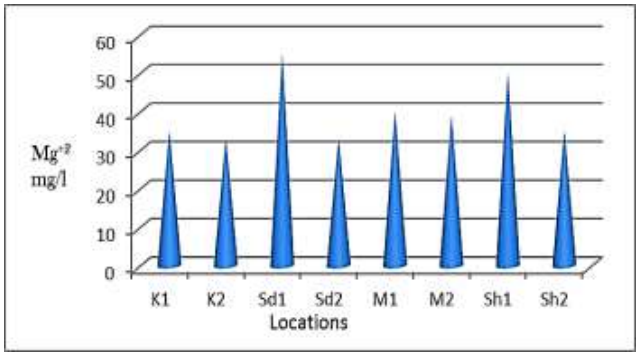

Figure 11. Magnesium ion concentration values

f) Chloride

The Chloride ion concentration values are ranged between (130-139) mg/l with an average of 134.8 mg/l, which was within the standard limits of 200 mg/l as shown in figure 12. On the other hand, the laboratory results that ranged between (190-220) mg/l, with an average of 209 mg/l was above the permissible standard limit. It could be due to the addition of Chloride as a sterile substance for water.

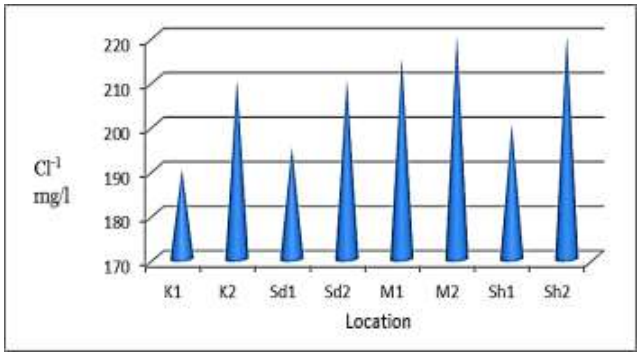

Figure 12. Chloride ion concentration values

g) Sulfate

The sulfate ion values are ranged between (315-367) mg/l with an average of 344.9 mg/l. The concentration of sulfate ion is higher than the permissible standard limit of 250 mg/l according to the Iraqi specification (I.S. 1996)[24]. The results are shown in figure 13.

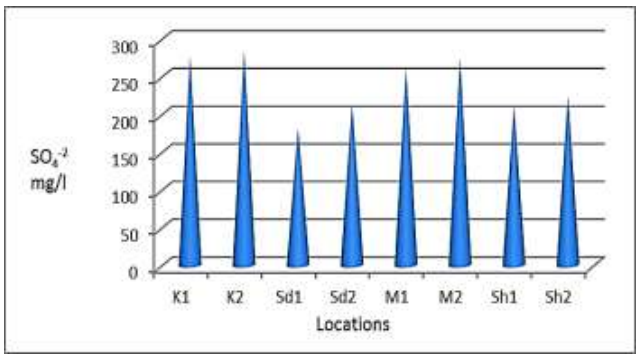

Figure 13. Sulfate ion concentration values

h) Sodium

Sodium ion values are ranged between (77-95) mg/l with an average of 90 mg/l. It is observed that the sodium concentration is lower than the standard value of 200 mg/l according to (I.S.1996)[24] and as shown in figure 14. The same applies to laboratory results, which are ranged between (50.19-106.63) mg/l with an average of 88.17 mg/l, where it is noticed that they exceeded the allowed standard limit of 200 mg/l. The increase in sodium concentration has an adverse effect on health of patients with high blood pressure[27].

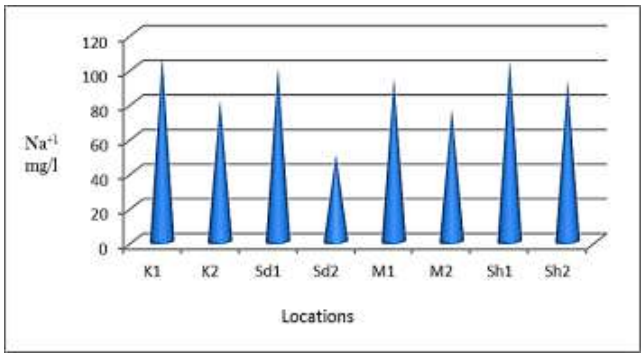

Figure 14. Sodium ion concentration values

i) Potassium

Potassium ion concentration values are ranged between (5-6.2) mg/l with an average of 5.88 mg/l as it did not exceed the standard value of 10 mg/l, according to (I.S. 1996)[24] as shown in figure 15. Likewise, when comparing the laboratory results, which are ranged between (12.75-16.70) mg/l with an average of 14.72 mg/l, it is noted that it did not exceed the allowable standard limit. Table 4 shows the extent and rate of chemical properties and their comparison with standard specifications and laboratory results.

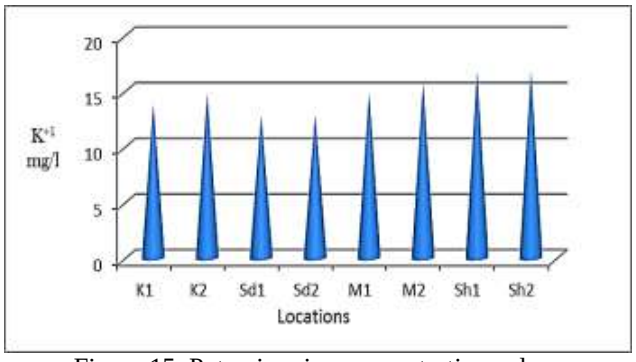

Figure 15. Potassium ion concentration values

Table (4) shows the scope and rate of chemical tests and their comparison with standard specifications and laboratory results

Sample	Results of Khalidiya water directorate tests									Laboratory tests									
	pH	T.H	$CaCO_3$	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	SO_4^{-2}	Cl^{-1}	pH	T.H	NO_3^-	$CaCO_3$	Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	SO_4^{-2}	Cl^{-1}
K1	7.9	447	99	115	38	95	6.2	351	139	7.63	460	6.8	155.2	80	35	106.63	13.73	276	190
K2	8.2	436	95	116	35	92	6	367	135	8.1			160.3	72	33	81.20	14.71	283	210
Sd1	7.9	440	97	113	38	95	6.2	351	135	7.65	530	6.7	135.8	40	55	100.2	12.74	181	195
Sd2	8.3	435	94	115	35	94	6	355	137	7.91			130.1	104	33	50.19	12.79	213	210
M1	7.7	47	97	116	49	78	5.2	315	132	7.77	47	3.6	174.6	88	40	93.92	14.72	260	21

		4									8							5
M2	8.1	472	102	115	48	77	5	320	138	7.86			172.2	120	39	75.91	15.70	273	220
Sh1	8	442	100	117	38	94	6.2	351	130	7.69	515	6.3	164.9	76	50	104.51	16.69	210	200
Sh2	8.3	439	96	113	38	95	6.2	349	132	8.2			169.3	108	35	92.86	16.70	224	220
Range	7.7 – 8.3	435 - 474	94 - 102	113 - 117	35 - 49	77 - 95	5 - 6.2	315 - 367	130 - 139	7.63 - 8.2	460 - 530	3.6 - 6.8	130.1 - 174.6	40 - 120	33 - 55	50.19 - 106.63	12.75 - 16.70	181 - 283	190 - 220
Average	8.05	398	109.2	115	39.88	90	5.88	344.9	134.8	7.85	496	5.85	157.8	86	40	88.17	14.72	240	209
I.S.	6.5 – 8.5	500	125 - 200	150	100	200	10	400	350	6.5 - 8.5	500		125 - 200	200	50	200	10	250	250

3- Biological properties

The results of the biological tests indicate that all properties (residual Chloride and MPN Total /100, MPN fecal coliform /100 ml, plate count /1ml) are within the permissible limits as shown in table 5. The results are compared with allowable standard limits for bacteria in water which is 200 bacteria cells (fecal coliform) per 100 ml[(22)].

Table 5. Laboratory results for bacteria types and values

Sample	K1	K2	Sd1	Sd2	M1	M2	Sh1	Sh2
E. Coli	4	14	8	15	7	12	7	12
Total plat count	98	214	258	93	102	311	84	292

Statistical Analysis

Direct and inverse correlations (some with significant correlations) were found between chemical and physical measurements of different water samples and for all study areas using the SPSS program as shown in table 6 which tabulates the correlation matrix for all chemical and physical measurements[(28)].

Table 6: Correlation matrix for the chemical and physical properties of drinking water.

		Cl^{-1}	SO_4^{-2}	K^{+1}	Na^{+}_{1}	Mg^{+2}	Ca^{+}_{2}	$CaCO_3$	NO_3^{-}	T.H	pH	NTU	TSS	TDS	E.C
Cl^{-1}	Person	1	611.	-142	-004	-410	415.	.221	-059	-165	056.	-.024	-006	-256	-192
	Sig.(2-taild)		108.	-.737.	-.992.	-.313.	307.	.598	-.889.	-.697.	895.	-.956	-.990.	-.526.	-.649.
SO_4^{-2}	Person	611.	1	038.	-072	-508	200.	.274	-293	-365	326.	.188	342.	265.	015.
	Sig.(2-taild)	108.		929.	-.866.	-.199.	635.	.511	-.482.	-.373.	430.	.656	407.	527.	972.
K^{+1}	Person	-142	038.	1	379.	-149	264.	.632	-073	-084	364.	.122	238.	246.	102.
	Sig.(2-taild)	-.737.	929.		354.	-.724.	527.	.093	-.865.	-843.	375.	.773	571.	527.	809.
Na^{+1}	Person	-004	-072	379.	1	164.	-622	.024	772.	685.	-434	-.603	-708	-188	-792
	Sig.(2-taild)	-.992.	-.866.	354.		698.	-.100.	.955	025.	061.	-.282.	-.113	-.049.	-.656.	-.019.
Mg^{+2}	Person	-410	-508	-194	164.	1	-375	.136	570.	-675	-811	-.737	-581	-734	-107
	Sig.(2-taild)	-.313.	-.199.	-.724.	698.		-.360	.749	140.	-.066.	-.015.	-.037	-.131.	-.038.	-.800.
Ca^{+2}	Person	415.	200.	264.	-622	-375	1	.529	-693	-657	574.	.534	690.	086.	634.
	Sig.(2-taild)	397.	635.	527.	-.100.	-.360.		178	-.057.	-.076.	137.	.173	058.	839.	091.
$CaCO_3$	Person	221.	274.	632.	024.	136.	529.	1	-177	-064	088.	-.157	215.	-157	254.
	Sig.(2-taild)	598.	511.	093.	955.	749.	178.		-.674.	-.879.	836.	-.710	609.	-.710.	544.
NO_3^{-}	Person	-059	-293	-073	772.	570.	-693	-.177-.674	1	957.	-866	-.871	-961	-598	-846
	Sig.(	-.	-.	-.	025	140	-.			000	-.	-	-.	-.	-.

	2-taild)	889.	482.	865.	.	.	057.				005.	.005	000	117.	008.
T.H	Person	-165	-365	-084	685.	-675	-657	-.064-	957.	1	-914	-935.	-948	-589	-794
	Sig.(2-taild)	-.697.	-.373.	-.843.	061.	-.066.	-.076.	.879	000		-.001.	-.001	-.000	-.124.	-.019.
pH	Person	056.	326.	364.	-434	-811	574.	.088	-866	-914	1	.943	910.	797.	617.
	Sig.(2-taild)	895	430	375.	-.282.	-.015.	137.	.836	-.005.	-.001.		000	002.	018.	103.
NUT	Person	-024	188.	122.	-603	-737	534.	-.157-	-871	-935	943.	1	901.	728.	688.
	Sig.(2-taild)	-.956.	656.	773.	-.113.	-.037.	173.	.710	-.005.	-.001.	000		002.	041.	059.
TSS	Person	-006	342.	238.	-708	-581	690.	.215	-961	-948	910.	.901	1	649.	844.
	Sig.(2-taild)	-.990.	407.	571.	-.049.	-.131.	058.	.609	-.000	-.000	002.	.002		081.	008.
TDS	Person	-256	265.	246.	-188	-734	086.	-.157-	-598	-589	797.	.728	649.	1	263.
	Sig.(2-taild)	-.526.	527.	527.	-.656.	-.038.	839.	.710	-.117.	-.124.	018.	.041	081.		530
E.C	Person	-192	015.	102.	-792	-107	634.	.254	-846	-794	617.	.688	844.	263.	1
	Sig.(2-taild)	698.	972.	809.	019.	800.	091.	.544	008.	019.	103.	.059	008.	530.	

*Correlation is significant at the 0.05 level (2-tailed).,
**Correlation is significant at the 0.01 level (2-tailed) .

Table 6 shows the correlation matrix for the chemical and physical properties of drinking water for all study areas. Accordingly, the following can be concluded:

1. A medium strength positive correlation of Chloride ion with ions (Ca^{+2} and SO_4^{-2}) with significant correlation.
2. A weak positive correlation of sulfate ion with (pH, TSS). There is a negative correlation of sulfate ion with (T.H, pH, Mg^{+2} and Na^{+}).
3. There is a weak correlation of potassium ion with (Na^{+}, pH). It can be noted that there is a strong positive correlation with ($CaCO_3$).
4. A medium strength positive correlation of magnesium ion with NO_3^{-} and negative correlation with each of (E.C, NTU, NO_3^{-}, T.H, TSS, TDS and Ca^{+2}).
5. A medium strength positive correlation of calcium ion with (E.C, NTU, pH, TSS and $CaCO_3$) and negative correlation with both of (NO_3^{-} and T.H).
6. A negative correlation of calcium carbonate with (NTU, NO_3^{-}, T.H and TDS).
7. A very strong positive correlation of NO_3^{-} ion with T.H and negative relationship with (E.C, NTU, pH and TSS).
8. There is a negative correlation of T.H with each of (E.C, NTU, pH, TSS and TDS).
9. A very strong positive correlation of pH with (E.C, NTU, TSS and TDS).
10. There is a very strong positive correlation of NTU with each of (E.C, TSS and TDS)
11. A very strong positive correlation of TSS with (TDS and E.C).

Conclusions

1. The physical properties do not exceed the permitted Iraqi and international standard values. There was only one rise in the values of electrical conductivity.
2. All chemical properties did not exceed the allowed Iraqi and international standard values except for the high concentration of magnesium and sulfate.
3. The study showed that all biological tests were within the limits permitted locally and globally.
4. Using the SPSS statistical program, it was found that there is a linear correlation of some measured values, as well as an inverse correlation of other values and a significant correlation between chemical and physical measurements of different water models for all study areas.

Recommendations

1. Continuing in carrying out tests periodically, expand water related tests such as trace elements, as well as biological tests and expand study areas so that we can determine the water's suitability for drinking
2. Developing water treatment processes in treatment plants through monitoring and treating water quality in addition to training staff
3. Studying the different materials and wastes disposed to the water and comparing the water components with local and international standards or standards.
4. Performing a statistical analysis using time series methods to predict future river quality results.

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