زانکۆی سەلاحەدین - هەولێر
Salahaddin University-Erbil

Assessment of Groundwater and Surface water Quality in Erbil city, Kurdistan Region of Iraq.

Research Project

Submitted to the Department of (Biology) in partial fulfillment of the requirements for the degree of **BSc.** in **Biology**

By

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Supervised by

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CERTIFICATE

This research project has been written under my supervision and has been submitted to the department of biology for the award of the degree of **BSc.** in **Biology** with my approval as a supervisor.

Name: **Dr. Abdulla H. Aziz**

Date: **April, 2023**

I confirm that all requirements have been fulfilled.

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Head of the Department of biology

Date: **April, 2023**

DEDICATION

This effort I dedicate to **Allah** Almighty, my lord, my powerful foundation, my source of inspiration, wisdom, knowledge, and understanding. Throughout this project, he was the source of my energy.

Srwsht

ACKNOWLEDGMENTS

To begin with, I thank (Allah) for His blessing, which made me able to complete and perform this study with success, the lord of the universe, blessing, and peace be on Muhammad (Allah's peace and prayers be upon him).

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My gratitude and appreciation are dedicated to the presidency of Salahaddin University-Erbil, the deanery of College of Education and to the head of Biology Department for their necessary facilities during the work.

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Finally, I want to say thanks to all those I forgot here to mention his/her name, who assisted me even by one useful scientific word directly or indirectly.

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ABSTRACT

An ecological investigation was conducted at nineteen sites of ground and surface water sources used by public for drinking water to evaluate water quality by using physical and chemical properties of water samples. Water samples were collected during October, November and December 2022 in addition to January 2023. Some physical and chemical parameters were analyzed including, pH, EC, TDS, alkalinity, acidity, hardness, calcium, magnesium, chloride, nitrite, nitrate and phosphate. pH value of all the studied sites were found to lie in the alkaline side of neutrality and ranged between 7 and 8.1.

Electrical conductivity values were ranged between 357 and 797 µS/cm at sites Karezan and Baghy Shar during November 2022. It is worth to mention that sites located inside the 30m circle (i.e. Shaqamy Pzishkan and Taajil) were characterized by high levels of EC values and exceeds the maximum permission value of 500 µS/cm. In the same fashion, Total dissolved solids TDS fluctuated from 180 to 400 mg/l during the study period. All studied sites with Erbil city were remained within the limits proposed by (WHO, 2022). Chloride ion concentration ranged between 2 and 49.98 mg/l at Badawa site during November 2022 and Baghy Shar site during January 2023 respectively.

Alkalinity results revealed that the value ranged from 160 to 394 mg/l at Setaqan site during December 2022 and Baghy Shar site during January 2023. Al studied sited lies with maximum permission level of (250 mg/l) except for sites Baghy Shar, Shorsh, Mufty and 32 Park with values above allowable limits. All studied sites characterized by low concentrations of nitrite and never exceed 1 mg/l except 32 Park site during November 2022. During the whole study period, the concentration of phosphorus was within the maximum allowable level of 10 mg/l.

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1. INTRODUCTION

Freshwater makes up only 3% of the water on the earth, and two thirds of that is trapped in glaciers and ice caps. This means that only 1% of the earth's water is available in sources such as lakes, rivers, and groundwater to support rich ecosystems of plants and animals (Caso, 2010). Fresh water is a very valuable resource, and getting more valuable every day. Each day, our limited water supplies have to be shared by a larger population. Humans need about 50 L of water a day to stay healthy (e.g. for drinking, cooking, washing, sanitation). With increasing populations and increased technological growth, the ecosystems we depend on are under greater stress. The Earth's supply of accessible fresh waters is especially at risk. One third of people in the developing world do not have access to safe drinking water (Desonie, 2008).

Groundwater occurs almost everywhere beneath the earth surface not in a single widespread aquifer but in thousands of local aquifer systems and compartments that have similar characters. Knowledge of the occurrence, replenishment, and recovery of groundwater has special significance in arid and semi-arid regions due to discrepancy in monsoonal rainfall, insufficient surface waters and over drafting of groundwater resources. Groundwater quality depends on the quality of recharged water, atmospheric precipitation, inland surface water, and on sub-surface geochemical processes. Temporal changes in the origin and constitution of the recharged water, hydrologic and human factors, may cause periodic changes in groundwater quality.

Groundwater is one of the vital and most vulnerable sources of earth's fresh water. It is however, favored over surface water due to a number of specific properties including, higher quality, lower possibility of direct contamination, lesser vulnerability to seasonal and perennial fluctuations, and a balanced distribution over many regions of the world.

The quality of groundwater depends on the composition of the recharge water, the interactions between the water and the soil, soil – gas and rocks with unsaturated zone,

and the residence time and reactions that place within the aquifer. Therefore, considerable variation of water quality can be found, especially where rocks of different compositions and solubility occur. (Bartram and Balance, 1996). In addition to that growth, death and decomposition of aquatic plants and algae will affect the concentration of nitrogenous and phosphorus nutrients, pH, carbonates, dissolved oxygen and other chemicals sensitive to oxidation/ reduction conditions. (Leggett, et. al. 2001). Also the lithology (rock composition) affect the quality of groundwater because the susceptibility of rocks to weathering different and ranges from 1for granite to 12 for limestone.

The quality of surface and ground water is a major factor affecting human health and ecological systems, especially around urban areas, since rivers and their tributaries passing through cities receive a multitude of contaminants released from industrial, domestic/sewage, and agricultural effluents. Anthropogenic influences such as urbanization, industrial and agricultural practices, chemical spill accidents, dam construction, and natural processes like erosion and climatic conditions, could each affect surface and ground water quality (Zhang, et al., 2009).

The aim of the present study is to evaluate the quality of surface and ground water sources within Erbil city by using the most important physical and chemical properties of water quality include pH, EC, TDS, Turbidity, Chloride, Alkalinity, Hardness, Nitrite and Phosphate.

2. LITERATURE REVIEWS

In Iraq from the last five decades in previous century the beginning of the ecological studies in inland waters were appeared and developed with developing universities and scientific research centers. During the last two decades several studies conducted worldwide. Ward *et al*. 1995 studied Drinking water Nitrate of 156 cases and 527 controls who used Nebraska community supplies, average nitrate exposure was estimated from 1947 through 1979, result show long term consumption of community water with average nitrate levels in the highest quality. Stuart, *et al*. 1995 working surrey of Nitrate contamination in shallow domestic drinking water wells of the Inner coastal plain of Georgia, several variables were measured ,including PH ,specific conductivity, dissolved oxygen ,temperature , nitrate ,total hardness ,calcium ,magnesium and bicarbonate , in some well sulfate ,chloride potassium ,iron ,and manganese .content were also determined , in face 56% of the wells sampled showed no detectable signs of nitrate or nitrate contamination, result of the nature of the agricultural practice used in this region and or the effect of nature denitrification.

Cantor, 1996 studied drinking water and cancer used disinfection by products nitrite ,arsenic and other metals ,show nitrate in grounds water has increased greatly over the years , and the demonstration of endogenous nitrosation among highly exposed subjects raises cancers of elevated cancer risk. Shittu, *et al.* 2008 Studied phsico-chemical and bacteriological Analyses of water used for drinking and swimming purposes in Abeokuta, Nigeria, The did not comply with turbidy and ,mg standards respectively ,all others were within the standards set for PH Color, Total Solids, acidit. The result obtained were compared with WHO and EPA guidelines.

Tistaprasai, *et al*. 2007 Stuided microbiological analysis of 132 drinking water of kathmandu valley 132 drinking water samples were randomly collected from 49 tube wells, 57 wells, 17 taps and 9 stone spouts indifferent places of kathmandu valley. Saeedi,

et al. 2009 studied development of ground water quality index the water quality index is a mathematical instrument used to transform large quantites of water quality data into a single number which represent the water quality level this aim of identifying places with best quality for drinking within the Qazvin province west central of iran result show that observed

Mareh. 2010 studied Assessment of sewer source contamination of drinking water wells using tracers and Human Enteric viruses of a total of 33 wells from 14 community viruses, result show along with exclusion of wells for additional investigation. Pritchard, *et al*. 2007 studied the biological, chemical and physical drinking water quality from shallow wells. The result of microbiological analysis show that the drinking water quality is very poor. Cidu, *et al*. 2010 studied drinking water quality of 37 bottled water and 15 top water source from Italian market & municipal pilline respectively result show that CL,SO4 , NO3 exceeding the Italian regulations for drinking water. Yisa and Jimoh, 2010 Analytical studied on water quality Index of River Landzu this was Dony by subjecting the 120 water sample collected to comprehensive physic-chemical analysis using APHA standard methods of analysis .result show that the WQI for the sample was 171.85 this analysis when compared with world health organization (WHO)and Nigerian Industrial standard (NIS)Permissible limit indicated that the river was polluted and so the water is not safe .

Wang, *et al*. 2012 studied assessment of surface water quality via multivariate statical techniques a case study of the Songhua River harbin region china of six different sites in the region over afive year monitoring period (2005-2009). Xua, *et al*. 2012 studied assessment and spatiotemporal variation analysis of water quality in the zhangwieinau river, basin, china , in this study fuzzy comprehensive analysis and two statistical methods including cluster analysis and seasonal kendall test method were used to evaluate the spatiotemporal variation of water quality in zhangweinan river basin,result show that

provide may useful information for better pollution control strategies in the zhangweinan river basin.

Selvakumar, *et al*. 2014 Studied ground water quality and its suitability for drinking and irrigational use in the southern Tiruchirappalli district Tamil Nadu, India of 20 ground water bore wells of southern Tirachirappalli distrct and analyzed for various hydeogochemical parameters, such as PH and Calcium. Result show that dominant hydrological facies for ground water quality suggest the majority of the water samples being to high medium salinity with low alkali hazards. Yusuf, *et al*. 2017 Studied drinking water quality physical and chemical evaluation of tap and packaged waters from eight local government areas, results showed that the concentration of the water constituents in both tap and packaged water ware within the maximum permission levels proposed by national and international agencies.

Rehman, *et al*. 2018 studied assessment of ground water quality of dere Ismail khaw pakistan, using multivariate statisical Approch, the collected water samples were analyzed for 13 water quality parameters, such as total dissolved solids TDS, Sulfate …..etc, result show regular monitoring programs for ground water quality are the dire need of hour to suggest remedial and management strategies in order to safe guard the health of local masses.

Donald and Blessing, 2019 studied index approach to water quality assessment of south Nigerian river this studied between January and June 2018 in 3stations in relation to anthropogenic impacts and suitability to support aquatic biodiversity using water quality indices result show that the indices in the three stations effectively captured the effect of the anthropogenic activities in the river and showed that the water quality was suitable to sustain biodiversity.

3.MATERIALS and METHODS

3.1. Water sampling:

Water samples from 19 different sites were collected monthly intervals from October 2022 to January 2023. Surface and groundwater samples were taken for physical, and chemical analysis using polyethylene bottles which was rinsed twice with water sample before filling it.

3.1. Physical analysis:

3.1.1. Hydrogen ion concentration (pH):

It was measured directly in the field by Electrometric method using a portable pH-meter model (HANNA instrument, Portugal). The instrument was calibrated before each sampling using buffer solutions of (pH=4, 7 and 9) as described by (APHA, 2012).

3.1.2. Electrical Conductivity (EC):

It was measured in the field using a portable conductivity meter model (HI 9811, HANNA instruments, 2000) calibrated with (0.01M) potassium chloride solution before each sampling, the results were expressed in $\mu S.cm^{-1}$ as described by (APHA, 2012).

3.1.3. Total Dissolved Solids (TDS):

Measured in the field using a portable TDS-meter model (HI9811, HANNA instruments, 2000), the results were expressed in mg l^{-1} (APHA, 2012).

3.2. Chemical analysis:

3.2.1. Total Alkalinity:

It was determined in the laboratory by Titration method recommended by (APHA, 2012)., the results were expressed in mg $CaCO_3$ l^{-1} using the formula bellow:

Alkalinityas$mgCaCO_3$ l^{-1} =A*B*50000/ml of sample.

Where: A= ml of standard acid titrant. B= normality of standard acid.

3.2.2. Total Acidity:

Acidity was determined by titration method as described by (APHA, 2012)., the results were expressed in mg $CaCO_3$ l^{-1} using the following formula:

Acidityas$mgCaCO_3$ l^{-1} =A*B*50000/ml of sample.

Where: A=ml of standard NaOH titrant used. B= normality of standard NaOH.

3.2.3. Total Hardness:

It was determined by EDTA titrimetric method as described by (APHA, 2012)., using Erichrom Black T as indicator and buffer solution of pH 10, the results were expressed in $mgCaCO_3$ l^{-1} using the formula bellow: Hardnessas$mgCaCO_3$ l^{-1} =A*B*1000/ml of sample.

Where: A=ml titration for sample. B=$mgCaCO_3$equivalentto 1ml EDTA titrant.

3.2.4. Chloride (Cl^-):

It was determined by Argentometric method using silver nitrate titrants described by (APHA, 2012)., the results were expressed in mg Cl^- l^{-1} by equation:

mg Cl^- l^{-1}=(A-B)*N*35450/ml of sample.

Where: A= ml titration for sample. B= ml titration for blank. N=normality of $AgNO_3$.

3.2.5. Nitrite (NO_2):

Determined by Spectrophotometric method using color reagent composed of a mixture of Phosphoric acid, Sulfanileamide and N-(1-naphthyl)-ethylenediamine dihydrocholride using wavelength of 543 nm in 1cm cuvette cell the results were expressed in mg l_{-1} (APHA, 2012).

3.2.6. Reactive Phosphorus (PO_4^{-3}):

Reactive phosphorus was determined by Stannous Chloride Method using stannous chloride and ammonium molybdate to form molybdenum blue. The absorbance was

measured in 1cm cuvette cell at the wavelength of 690 nm. The results were obtained through a standard curve and expressed in mg $P\text{-}PO_4\ l^{-1}$ (APHA, 2012).

3.2.7. Calcium (Ca^{+2}):

It was determined by EDTA titrimetric method as described by (APHA, 2012) using murexide as indicator and buffer solution of pH 12.

The results were expressed in $mgCa^{+2}\ l^{-1}$, the following equation was used:

$mgCa^{+2}\ l^{-1}$=A*B*400.8/ml of sample.

Where: A=ml titrant for sample.

B= mg CaCO3 equivalent to 1ml EDTA titrant at the calcium indicator endpoint.

3.2.8. Magnesium (Mg^{+2}):

Calculated by subtraction of EDTA volume used for calcium titration from EDTA volume used for total hardness as described by APHA (2012). The results were expressed in mg $Mg^{2+}\ l^{-1}$, the following equation was used:

mg $Mg^{2+}\ l^{-1}$= [total hardness (as mg $CaCO_3\ l^{-1}$) – calcium hardness (as $mgCaCO_3\ l^{-1}$)] x 0.243

4.RESULTS and DISCUSSIONS

The results of physico-chemical properties of analyzed water samples is summarized in Tables 1, 2, 3 and 4. pH is a measure of the activity of Hydrogen ions (H^+) in a solution therefore, solution is either acidic (pH less than 7) or alkaline (pH greater than 7), according to WHO and Iraqi Standards for drinking bottled water, pH value ranges (6.5 – 8.5). The pH values ranged from 7.4-8.1at Taajil and Karezan sites during the October 2022, while it was between 7 and 8.1 at Baghy Shar and Shaqamy Pzishkan during November 2022. On the other hand, all pH values were on the right side of neutrality with pH values above 7.

Table 1: Physico-chemical components of nineteen water sites in Erbil city during October 2022.

Sites	pH	EC µS/ cm	TDS mg/l	Cl^- mg/l	Alk. mg/l	Acid. mg/l	Hard. mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	PO_4 mg/l	NO_2 mg/l	NO_3 mg/l
Shaqamy Pzishkan	8.00	477	280	6.00	212	4.00	**260**	**72.00**	33.60	0.12	0.82	-
Barrewabaraiaty Parwarda	7.70	400	188	8.00	220	6.00	**252**	**68.40**	33.12	0.11	0.69	-
Baghy Shar	7.80	487	229	9.00	240	4.00	**280**	**74.40**	37.44	**0.10**	0.72	-
Taajil	**7.40**	451	212	**14.00**	220	6.00	**252**	**64.80**	34.56	**0.10**	0.68	-
Tairawa	7.80	415	**194**	6.00	**160**	4.00	240	**55.20**	35.52	0.14	0.63	-
Setaqan	7.80	486	243	8.00	188	**2.00**	**256**	43.20	44.16	0.16	0.65	-
Zaniary	7.80	**509**	254	10.00	212	4.00	240	**64.80**	31.68	0.12	0.66	-
Bakhtiary	7.70	472	234	7.00	232	6.00	244	**50.40**	38.40	**0.10**	0.76	-
Shorsh	7.90	**539**	271	12.00	**260**	4.00	**256**	36.00	**47.04**	**0.10**	0.73	-
Mufty	7.80	489	246	10.00	200	4.00	232	48.00	36.48	0.11	0.65	-
Nawroz	7.70	**519**	257	10.00	180	**10.00**	248	38.40	44.16	0.11	0.62	-
32 Park	7.50	**701**	**351**	33.99	220	8.00	240	36.00	43.20	0.11	0.77	-
Berkot 1	7.80	484	243	**4.00**	236	**2.00**	232	40.80	39.36	**0.10**	0.60	-
Berkot 2	7.80	439	220	7.00	188	4.00	240	48.00	38.40	0.11	0.74	-
Karezan	**8.10**	**397**	201	8.00	180	2.00	200	39.60	32.16	**0.10**	**0.88**	-
Havallan	7.80	473	235	6.00	184	4.00	208	**21.60**	41.28	0.16	0.70	-
Badawa	7.80	485	241	8.00	196	4.00	240	30.00	45.60	0.11	0.73	-
Shady	7.70	454	229	10.00	220	6.00	**192**	38.40	**30.72**	**0.19**	**0.61**	-
Kotr City	7.90	433	218	10.00	212	4.00	200	31.20	35.52	0.15	0.67	-
WHO-WQS	**6.5-8.5**	**500**	**300**	**250**	**250**	**250**	**250**	**50**	**50**	**1**	**1**	**10**

Electrical Conductivity (EC) is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentrations, mobility, and on the temperature of measurement (APHA, 2012). Electrical conductivity EC results (Tables 1, 2, 3 and 4) showed that the EC values were ranged between 357 and 797 µS/cm at sites Karezan and Baghy Shar during November 2022. It is worth to mention that sites located inside the 30m circle (i.e. Shaqamy Pzishkan and Taajil) were characterized by high levels of EC values and exceeds the maximum permission value of 500 µS/cm. In the same fashion, Total dissolved solids TDS fluctuated from 180 to 400 mg/l during the study period. All studied sites with Erbil city were remained within the limits proposed by (IQS, 2001 and WHO, 2022).

Table 2: Physico-chemical components of nineteen water sites in Erbil city during November 2022.

Sites	pH	EC µS/cm	TDS mg/l	Cl^- mg/l	Alk. mg/l	Acid. mg/l	Hard. mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	PO_4 mg/l	NO_2 mg/l	NO_3 mg/l
Shaqamy Pzishkan	**8.10**	**561**	280	8.00	200	**4.00**	172	**52.80**	20.16	**0.604**	0.232	-
Barrewabaraiaty Parwarda	8.00	483	245	10.00	212	6.00	200	**57.60**	24.96	0.283	0.222	-
Baghy Shar	**7.00**	**797**	**400**	**33.99**	**292**	**14.00**	**244**	**81.60**	**25.92**	0.337	**0.209**	-
Taajil	7.40	**503**	254	17.99	200	8.00	144	**60.00**	10.56	0.328	0.216	-
Tairawa	7.70	491	246	12.00	212	**4.00**	172	**52.80**	20.16	0.326	0.214	-
Setaqan	7.60	494	248	27.99	208	6.00	152	**50.40**	16.32	0.189	0.294	-
Zaniary	7.70	476	239	10.00	184	8.00	200	**69.60**	20.16	0.191	0.224	-
Bakhtiary	7.40	**530**	265	16.00	208	8.00	144	**60.00**	10.56	0.265	0.235	-
Shorsh	7.50	449	224	14.00	172	6.00	148	**72.00**	**6.72**	0.218	0.245	-
Mufty	7.60	**506**	253	12.00	204	6.00	140	**62.40**	8.64	0.203	0.219	-
Nawroz	7.60	486	244	16.00	188	8.00	124	40.80	13.44	0.221	0.227	-
32 Park	7.10	**682**	**341**	29.99	256	12.00	184	55.20	22.08	**0.169**	**1.051**	-
Berkot 1	7.50	**503**	253	10.00	184	6.00	128	57.60	7.68	0.228	0.261	-
Berkot 2	7.40	465	233	12.00	208	6.00	172	48.00	22.08	0.278	0.224	-
Karezan	7.60	**357**	**180**	6.00	216	6.00	132	50.40	11.52	0.192	0.237	-
Havallan	7.60	497	246	12.00	196	6.00	128	43.20	13.44	0.234	0.214	-
Badawa	7.40	470	235	**2.00**	**164**	**4.00**	128	33.60	17.28	0.235	0.284	-
Shady	7.40	404	203	6.00	196	6.00	156	33.60	24	0.207	0.279	-
Kotr City	7.80	418	208	0.00	192	6.00	**108**	**26.40**	15.36	0.223	0.411	-
WHO-WQS	**6.5-8.5**	**500**	**300**	**250**	**250**	**250**	**250**	**50**	**50**	**1**	**1**	10

Chloride (Cl^-) is widely distributed in nature, generally from sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$) salts, and the presence of chloride in natural waters can be attributed to dissolution of salt deposits (WHO, 2022). Chloride ion concentration (Tables 1, 2, 3 and 4) ranged between 2 and 49.98 mg/l at Badawa site during November 2022 and Baghy Shar site during January 2023 respectively. All studied sites were within the permission level proposed by WHO and never exceeded 50 mg/l during the study period.

Table 3: Physico-chemical components of nineteen water sites in Erbil city during December 2022.

Sites	pH	EC µS/cm	TDS mg/l	Cl^- mg/l	Alk. mg/l	Acid. mg/l	Hard. mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	PO_4 mg/l	NO_2 mg/l	NO_3 mg/l
Shaqamy Pzishkan	8.00	477	280	6.00	212	4.00	**260**	**72**	33.6	0.115	0.819	0.122
Barrewabaraiaty Parwarda	8.00	477	280	6.00	212	4.00	**260**	**72**	33.6	0.115	0.819	0.122
Baghy Shar	7.70	400	**188**	8.00	220	6.00	**252**	**68**	33.1	0.112	0.690	0.125
Taajil	7.80	487	229	9.00	240	4.00	**280**	**74**	37.4	0.101	0.724	0.204
Tairawa	**7.40**	451	212	14.00	220	6.00	**252**	**65**	34.6	0.102	0.683	**0.279**
Setaqan	7.80	415	194	6.00	**160**	4.00	240	**55**	35.5	0.144	0.629	0.129
Zaniary	7.80	486	243	8.00	188	2.00	256	43	44.2	**0.163**	0.649	0.137
Bakhtiary	7.80	**509**	254	10.00	212	4.00	240	**65**	31.7	0.116	0.663	0.129
Shorsh	7.70	472	234	7.00	232	6.00	244	**50**	38.4	0.103	0.758	0.331
Mufty	7.90	**539**	271	12.00	**260**	4.00	256	36	47	**0.099**	0.731	**0.113**
Nawroz	7.80	489	246	10.00	200	4.00	232	48	36.5	0.106	0.649	0.133
32 Park	7.70	**519**	257	10.00	180	**10.00**	248	38	44.2	0.108	**0.615**	0.123
Berkot 1	7.50	**701**	**351**	**33.99**	220	8.00	240	36	43.2	0.105	0.771	0.131
Berkot 2	7.80	484	243	**4.00**	236	**2.00**	232	41	39.4	0.101	0.602	0.176
Karezan	7.80	439	220	7.00	188	4.00	240	48	38.4	0.114	0.737	0.200
Havallan	**8.10**	**397**	201	8.00	180	2.00	**200**	40	32.2	0.102	**0.880**	0.205
Badawa	7.80	473	235	6.00	184	4.00	208	**22**	41.3	0.156	0.697	0.120
Shady	7.80	485	241	8.00	196	4.00	240	30	**45.6**	0.111	0.731	0.205
Kotr City	7.70	454	229	10.00	220	6.00	192	38.40	**30.7**	0.194	0.609	0.220
WHO-WQS	**6.5-8.5**	**500**	**300**	**250**	**250**	**250**	**250**	**50**	**50**	**1**	**1**	**10**

The alkalinity of water is its capacity to neutralize acid, the amount of a strong acid needed to neutralize the alkalinity called the total alkalinity (APHA, 2012). Alkalinity results (Tables 1, 2,3 and 4) revealed that the value ranged from 160 to 394 mg/l at Setaqan site during December 2022 and Baghy Shar site during January 2023. Al studied sited lies

with maximum permission level of (250 mg/l) except for sites Baghy Shar, Shorsh, Mufty and 32 Park with values above allowable limits.

Acidity of water is its quantitative capacity to react with a strong base to a designated pH (APHA, 2012). Acidity levels (Tables 1, 2, 3 and 4) ranged between 2 to 14 at Setaqan, Berkot 1 and Berkot 2 during November and December 2022 and Baghy Shar during January 2023 respectevily. All studied sited were within the permission limit of 250 mg/l dusting the whole study period. On the other hand, Total hardness ranged from 108 to 316 mg/l at Kotr City during November 2022 and Baghy Shar during January 2023 respectively. All Study sites remained in safe levels during the studied period except Shaqamy Pzishkan, Taajil, Tairawa, Setaqan and Shorsh were above the maximum permission level of 250 mg/l. The Fluctuation were observed corresponding calcium and magnesium ions.

Table 4: Physico-chemical components of nineteen water sites in Erbil city during January 2023.

Sites	pH	EC µS/cm	TDS mg/l	Cl^- mg/l	Alk. mg/l	Acid. mg/l	Hard. mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	PO_4 mg/l	NO_2 mg/l	NO_3 mg/l
Shaqamy Pzishkan	8.20	496	240	12.00	236	10.00	232	19.20	48.0	0.164	0.310	**0.17**
Barrewabaraiaty Parwarda	7.80	474	241	14.00	212	14.00	228	**36.00**	40.3	0.156	0.341	**0.17**
Baghy Shar	**7.20**	**773**	**388**	**49.98**	**308**	**24.00**	**316**	31.20	**63.4**	0.149	0.287	0.20
Taajil	7.50	504	253	17.99	212	12.00	244	24.00	49	0.143	0.292	0.30
Tairawa	7.70	480	240	8.00	220	12.00	228	28.80	43.2	0.161	0.320	0.18
Setaqan	7.70	483	241	12.00	220	10.00	224	26.40	43.2	0.140	0.305	**0.17**
Zaniary	**8.00**	470	235	12.00	200	12.00	228	21.60	46.1	0.158	**0.339**	**0.17**
Bakhtiary	7.90	508	254	16.00	220	10.00	220	24.00	43.2	**0.131**	0.300	0.20
Shorsh	7.50	425	213	4.00	188	10.00	216	31.20	39.4	0.140	0.318	0.20
Mufty	7.50	439	219	31.99	**180**	12.00	220	28.80	41.3	**0.262**	0.281	0.19
Nawroz	7.70	478	239	12.00	224	12.00	240	24.00	48.0	0.154	0.268	**0.17**
32 Park	**7.20**	659	329	33.99	**304**	18.00	280	28.80	55.7	0.153	**0.232**	0.27
Berkot 1	7.40	435	217	29.99	192	10.00	200	26.40	37.4	0.164	0.310	0.20
Berkot 2	7.80	474	237	16.00	220	10.00	224	21.60	45.1	0.154	0.279	0.19
Karezan	7.60	439	219	10.00	208	10.00	236	24.00	47.0	0.169	0.258	0.19
Havallan	7.70	492	246	27.99	220	12.00	220	24.00	43.2	0.140	0.261	0.18
Badawa	7.40	422	212	17.99	208	10.00	208	24.00	40.3	0.149	0.284	**0.34**
Shady	7.50	**389**	**198**	8.00	212	**8.00**	180	21.60	34.6	0.169	0.279	0.22
Kotr City	**8.00**	406	203	**6.00**	216	10.00	**168**	**16.80**	**33.6**	0.160	0.263	0.27
WHO-WQS	**6.5-8.5**	**500**	**300**	**250**	**250**	**250**	**250**	**50**	**50**	**1**	**1**	**10**

Nitrite (NO_2) considered as an indicator of pollution in water when present in concentrations more than 1 mg/l as nitrite (APHA, 2012), however the concentration of nitrite in natural waters were low because its unstable form of nitrogen and immediately oxidized to nitrate or reduced to ammonia. All studied sites characterized by low concentrations of nitrite and never exceed 1 mg/l except 32 Park site during November 2022. Phosphorus (PO_4^{-3}) is a major nutrient required for normal growth of all algae, its essential for almost all cellular processes, i.e. biosynthesis of nucleic acids. The phosphorus concentration is often growth limiting in natural aqueous habitat (APHA, 2012). During the whole study period, the concentration of phosphorus was within the maximum allowable level of 10 mg/l.

5.CONCLUSIONS

During the period of the study, the following conclusions were noted:

1. The water quality of Baghy Shar, Taajil and Setaqan characterized by alkaline and hard water.
2. Baghy Shar and Taajil characterized by poor water quality, while Kotr City classified as the best water quality among all sites.
3. All Studied sites have nitrite levels below maximum permission levels.
4. All studied sites contain low nutrient concentrations of nitrogen and phosphorus.

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