



Assessment of the quality of drinking water of Halabja City- Iraqi Kurdistan

¹Faisal A. Salih , ²Attallah O. Kasem , ³Tareq H. Abdullah , ⁴Nasih F. Othman ,

⁵Muhammed B. Mina

^{1,2,4,5}Presidency of Sulaimani polytechnic university / Kurdistan Region of Iraq

**³Department of Medical laboratory Techniques/Halabjah technical institute/Kurdistan region of
Iraq**

¹faisal_ab1@yahoo.com,²K.C.C2006KCC@yahoo.com,³Envt.tarea@yahoo.com,

⁴Nasih.othman@yahoo.com, ⁵M.babakir@yahoo.com

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ABSTRACT

The quality of drinking water is a crucial factor for human health. The objective of this study was to assess the physico chemical and biological characteristics of the various sources of drinking water in the city of Halabja, Iraqi Kurdistan. Forty water samples were collected and analyzed for physic-chemical and biological characteristics. The study included 27 samples from municipality wells and 13 samples from household tap water. Analysis was done for physico-chemical parameters including pH, Electrical Conductivity (EC), total dissolved solids (TDS), total hardness (TH), Chloride (Cl⁻) , Alkalinity M, Alkalinity P, Aluminum (Al) , Copper (Cu) , Calcium (Ca) , Boron (B) and MPN .The results were compared with the standards prescribed by World Health Organization (WHO). All the physico -chemical parameters were found to be within allowable limits. It can, therefore, be concluded that the groundwater in the study area is suitable for drinking and other household purposes. But From the pH values it is clear that the ground water of the study area is alkaline in nature and the total hardness varies between 203-323 mg/l which indicate that water in the deep aquifer is hard hence suggested to Halabjah water director to soften the tube well water before consumption. There were no statistically significant differences between water samples from wells and households in terms of these parameters. Although the drinking water of the area is considered safe. Nevertheless biological surveillance is need especially in hot weather.



Keyword: Halabja, Drinking water, water quality, physico-chemical analysis, MPN.

تقييم نوعية مياه الشرب في مدينة حلبجة - كوردستان العراق

فيصل عبد الله صالح¹ ، عطا الله عمر قاسم² ، طارق حمة امين عبدالله³ ، ناصح عثمان⁴ ، محمد باكر مينة⁵

¹faisal_ab1@yahoo.com, ²K.C.C2006KCC@yahoo.com, ³Envt.tarea@yahoo.com

⁴M.babakir@yahoo.com, ⁵Nasih.othman@yahoo.com

^{1,2,4,5}رئاسة جامعة التقنية السليمانية / اقليم كردستان العراق

³قسم التحليلات المرضية / معهد التقى حلبجة / اقليم كردستان العراق

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الملخص

نوعية مياه الشرب هي عامل حاسم لصحة الإنسان. وكان الهدف من هذه الدراسة هو تقييم الخصائص الفيزيائية والكيميائية والبيولوجية لمصادر مختلفة من مياه الشرب في مدينة حلبجة في كوردستان العراق. حيث تم جمع أربعين عينة مياه وتم تحليلها لمعرفة الخصائص البيولوجية والفيزيائية والكيميائية . وشملت الدراسة 27 عينة من مياه الآبار البلدية و 13 عينة من مياه الحنفية المنزلية . وقد تم تحليل باراميترات الفيزيائية والكيميائية بما في ذلك درجة الحموضة، التوصيل الكهربائي (EC)، المواد الصلبة الذائبة (TDS)، العسر الكلي (TH)، كلوريد (الكلور)، Alkalinity P، Alkalinity M، والألمنيوم (Al)، والنحاس (Cu) والكالسيوم (Ca)، وتمت مقارنة البورون (B) مع MPN . وقارنت النتائج مع المعايير التي تنص عليها منظمة الصحة العالمية (WHO) . تم العثور على جميع باراميترات الكيميائية - و الفيزيائية لتكون ضمن الحدود المسموح بها. وبالتالي يمكن أن نخلص إلى أن المياه الجوفية في منطقة الدراسة هي مناسبة لأغراض الشرب وللأغراض المنزلية الأخرى. ولكن من قيم الرقم الهيدروجيني من الواضح أن المياه الجوفية لمنطقة الدراسة هو قلوية في الطبيعة والعسر الكلي يتراوح بين 323-203 ملغم / لتر والتي تشير إلى أن المياه في طبقة المياه الجوفية العميقة هي صعبة وبالتالي اقترح على مدير مياه حلبجة تثبيت أنابيب الماء جيدا قبل الاستهلاك . لا توجد فروق ذات دلالة إحصائية



بين عينات المياه من الآبار ومياه البيوت من حيث هذه المعايير . على الرغم من أن مياه الشرب في منطقة تعتبر آمنة.

ومع ذلك فإنه يحتاج إلى المراقبة البيولوجية وخاصة في الطقس الحار.

الكلمات الدالة : طبقة ، ماء الشرب ، جودة الماء ، تحليل الفيزيائية و الكيميائية ، البيولوجية.

1. INTRODUCTION

Drinking water must be free from constituents hazardous to human health including some minerals, organic substances and pathogenic microorganisms. Large portions of the population in developing countries suffer from water-related health problems either due to shortage of safe drinking water or due to the presence of hazardous substances and microbial contamination of water [1]. Poor water quality is responsible for the death of an estimated 5 million children in the developing annually [2]. The Joint Monitoring Program (JMP) for Water Supply and Sanitation, implemented by the World Health Organization (WHO) and UNICEF, reports that 783 million people in the world (11% of the total population) have no access to safe water, 84% of whom live in rural areas [3]. Iraq has insufficient fresh water [4].The global environment is changing continuously due to unfavorable alteration of surroundings, holly as a by-product of man's actions, through direct or indirect effects of changes in energy pattern, radiation levels, chemical and physical constitution of organisms. These changes may affect man directly or through his supplies of water and of agricultural and other biological products, the most common types of pollution and pollutants discharged, encountered in domestic and industrial waste waters, along with their possible effects on the water resources are discussed. Chemicals are a major source of water Contamination [5], that introduced during water movement through geological materials, manufactured chemicals may cause problems. Fertilizers and pesticides are major contributors to water pollution; Nitrates from fertilizers are a common chemical pollutant of water. Heavy metals, sulphates, nitrates, chlorides, phosphates, carbonates, ammonia, pesticides, phenols, soaps and detergents are the common chemical pollutants. The WHO estimated that in developing countries about 80% of water pollution is a result of domestic waste. Water quality is used to describe the condition of the water, including its physical, chemical and biological characteristics,



usually with respect to its suitability for a particular purpose (i.e., drinking, swimming or fishing) [6]. The drinking water of Halabja city is supplied through two sources. Part of the city is supplied through Ahmadawa water project; a spring water source pumped to an elevated storage tank in Halabja where it is chlorinated and distributed through the water network. The other source includes 27 of deep wells pumped either directly to the network or pumped to elevated storage tanks after chlorination and then distributed to the water network. Suitability of water for various uses depends on type and concentration of dissolved minerals and groundwater has more mineral composition than surface water [7]. The quality of groundwater changes constantly in response to daily, seasonal and climatic factors. Continues monitoring of water quality parameters is highly crucial because changes in the quality of water have far reaching consequences in terms of its effects on man and biota [7]. Moreover, the inadequate management of water systems can cause serious problems in the availability and quality of water [8]. The aim of this study was the assessment of physical, chemical and biological quality of the drinking water in the city of Halabja for determines its suitability for drinking purposes.

2.MATERIALS AND METHODS

Halabjah is one of the district towns of Sulaimani governorate located 80 Km southeast of Sulaimani city at 35.1786° North and 45.9853° East with an elevation of 721 meters above the sea level **Figure (1)**. The city's main source of municipality drinking water is ground water provided by 27 of deep wells. These well are pumped to elevated storage tanks and then distributed to the households. In order to assessment of water, 40 sites were chosen for sample collection in the study area along the stretch of the stream Samples of water were collected from 27 municipality wells including one sample from Ahmadawa source and 13 households during the period from January to march 2014. Water samples were collected in pre-cleaned, sterilized glass bottles of 500 ml capacity and transported to the chemical laboratory at medical laboratory technical the technical institute of Halabja and the biomedical research laboratory of Sulaimani Polytechnic University in ice-cooled containers.

Analysis was done for physico-chemical parameters including pH, Electrical Conductivity (EC), total dissolved solids (TDS), total hardness (TH), Chloride (Cl), Alkalinity M, Alkalinity P,

Aluminum (Al), Copper (Cu), Calcium (Ca), Boron (B), by determined alkalinity – m and alkalinity – p we classify the alkalinity as hydroxide, carbonate and hydrogen carbonate.

We used multi-direct photometer for the analysis with standard reagents and deionizer water for experimental purposes (Photometer Multidirect Instruction, 2011).The bacteriological analysis was done using MPN method with MacConky broth multiple tube method for determining the most probable number of coliforms [9]. All the precautions were taken as given in APHA, AWWA, WPCF (2003), for sampling and analysis [10].



Figure (1): Location of Halabja at Sulaimani governoate.

3.RESULTS

Table (1) shows the results of samples from the municipality wells and Table (2) shows the same results for samples taken from households supplied by these wells. pH of all samples ranged from 6.3-8.08. Total dissolved solids (TDS) ranged from 209-705 and total hardness ranged from 203-323mg/l. The chloride content of water sample ranged from 0.6-24.5mg/l and calcium content was varied widely between 22-289 mg/l. The MPN index ranged from 1 to 6 per 100 ml. For values of other constituents please see Table (1) and (2). The mean values of physico-chemical parameters for all 40 samples are shown in Table (3). The mean TDS was 341(SD 129), the mean total hardness was 257(SD 32),the mean chloride content was 6.9 mg(SD 4.7) per

liter and the mean calcium was 107 mg (SD 59.8) per liter. The mean MPN index for contamination was 2.9 (SD 1.6) per 100 ml. We compared the mean values of these parameters between the wells and the household samples for any significant differences. Although there were some differences between the wells and household but none of these differences were statistically significant except temperature and alka-m. See Table (3). The mean values of alka-m for the well samples was 223 (SD 104) compared to 166 (SD 14) for the household samples, a difference which was statistically significant at 0.05%. Although MPN was higher in household samples than well samples (3.3 vs. 2.6) but this difference was not statistically significant.

Table (1): Physico-chemical analysis of water samples from Halabja municipality wells.

Sample No.		Chloride mg/l	PH	TDS mg/l	Conductivity ms/cm	Boron mg/l	Al mg/l	Cu mg/l	Ca mg/l	Alka-m	Hydroxidealkalinity	Carbonatealkalinity	Bicarbonatealkalinity	Temp	MPN index
Well 1	230	9.1	6.4	458	0.716	0.01	0.14	153	0.1	180	18	0	36	144	19.3
Well 2	296	9.9	7.3	388	0.606	0.01	0.05	289	0.3	152	10	0	20	132	19.8
Well 3	203	2.9	7.6	529.5	0.827	0.1	0.05	22	0.1	172	18	0	36	136	19.4
Well 4	274	3.1	6.5	304.6	0.476	0.01	1.4	188	0.1	169	20	0	40	129	19.4
Well 5	283	6.8	6.8	379	0.592	0.01	0.05	202	0.1	230	18	0	36	194	19.2
Well 6	310	5.1	6.4	667.3	1.043	0.01	0.15	284	0.1	241	15	0	30	211	19.4
Well 7	322	24.5	6.6	681.8	1.065	0.01	0.58	229	0.1	211	29	0	58	153	19.4
Well 8	257	5	6.3	705.2	1.102	0.05	0.41	115	0.1	217	19	0	38	179	19.3



Well 9	230	12.3	8.08	208.9	0.326	0.01	0.05	72	0.1	168	13	0	26	142	19.4	4
Well 10	210	8.3	7.75	219.8	0.343	0.01	0.05	73	0.1	170	18	0	36	134	19.4	3
Well 11	260	3.3	7.81	230.8	0.361	0.01	0.2	72	0.1	157	9	0	18	139	19.5	4
Well 12	258	7.7	7.85	243	0.38	0.01	0.05	73	0.1	189	5	0	0	189	19.4	2
Well 13	260	5.1	7.89	258	0.403	0.01	0.05	76	0.1	193	9	0	18	175	19.2	2
Well 14	281	5.2	7.9	272	0.425	0.01	0.16	76	0.1	481.5	5	0	0	481.5	19.4	1
Well 15	258	8.5	7.98	240.4	0.376	0.01	0.6	73	0.1	155	9	0	18	137	19.6	1
Well 16	266	0.7	7.93	316.2	0.494	0.01	0.05	81	0.1	470	14	0	28	442	19.4	2
Well 17	258	3.3	7.87	307.5	0.481	0.01	0.1	83	0.1	438.5	6	0	12	426.5	19.2	4
Well 18	259	3.3	7.68	288	0.45	0.01	0.15	72	0.1	471.4	8	0	16	455.4	19.6	3
Well 19	239	4.2	7.6	243	0.38	0.01	0.53	70	0.1	169	10	0	20	149	19.9	4
Well 20	323	4.8	7.43	330	0.516	0.01	0.05	73	0.1	244	11	0	22	222	19.4	1
Well 21	253	16	7.85	398.9	0.623	0.01	0.05	85	0.1	240	9	0	18	222	22	2
Well 22	216	7.9	7.47	272.1	0.425	0.01	0.05	75	0.1	172	11	0	22	150	19.5	1
Well 23	230	9.1	6.4	458	0.716	0.01	0.14	153	0.1	180	18	0	36	144	19.3	1
Well 24	296	9.9	7.3	388	0.606	0.01	0.05	289	0.3	152	10	0	20	132	19.8	3
Well 25	243	0.6	7.09	214.4	0.335	0.01	0.05	78	0.1	171	5	0	0	171	19.6	1



Well 26	274	3.1	6.5	304.6	0.476	0.01	1.4	188	0.1	169	20	0	40	129	19.4	1
Well 27	283	6.8	6.8	379	0.592	0.01	0.05	202	0.1	230	18	0	36	194	19.2	2

*Shaded cells indicate minimum and maximum values

Table (2): Physico-chemical analysis of water samples from Halabja households.

Sample	Hardness mg/l	Chloride mg/l	PH	TDS mg/l	Conductivity EC ms/cm	Al mg/l	Boron	Ca mg/l	Cu mg/l	Ala-k-n	Hydroxidealkalinity	Carbonatealkalinity	Bicarbonatealkalinity	Temp	MPN index	
House 1	211	5.7	7.1	239.3	0.374	0.01	0.05	176	0.1	164	5	0	0	164	19.4	2
House 2	275	2.7	6.8	376.3	0.588	0.01	0.05	152	0.1	149	13	0	26	123	19.5	2
House 3	208	11.7	7.92	212.1	0.331	0.01	0.05	73	0.1	151	17	0	34	117	19.2	1
House 4	269	6.4	7.83	253.9	0.397	0.01	0.31	76	0.1	196	8	0	16	180	20	3
House 5	311	3.7	8.06	231.3	0.361	0.01	0.05	81	0.1	162	5	0	0	162	19.8	3
House 6	211	4.5	7.41	372.4	0.582	0.01	0.09	72	0.1	153	11	0	22	131	15.6	6
House 7	270	6.2	7.71	287	0.448	0.01	0.15	76	0.1	165	16	0	32	133	15.5	6
House 8	211	6.7	7.64	283.5	0.443	0.01	0.05	79	0.1	163	13	0	26	137	16.3	1
House 9	253	14.3	7.86	342.8	0.536	0.01	0.05	87	0.1	179	7	0	14	165	17.3	4
House	214	5.3	7.87	281.6	0.44	0.01	0.26	84	0.1	168	9	0	18	150	18.4	3

10																	
House 11	279	3.1	6.7	353.7	0.553	0.01	0.05	158	0.1	172	14	0	28	144	19.6	5	
House 12	232	2.7	6.5	588.9	0.92	0.01	0.05	129	0.1	151	14	0	28	123	19.3	3	
House 13	259	3	8	254.3	0.397	0.01	0.05	79	0.1	452.8	11	0	22	430.8	19.8	6	

Table (3): Comparison of physic-chemical properties of water samples from municipality wells and corresponding households in Halabja

	All samples (n=40)	Well sample (n=27)	Household samples (n=11)	P value (t-test)
Characteristics		Mean (SD)	Mean (SD)	
Hardness mg/l	256.6(32.2)	262.2(6.1)	246.5(36.7)	0.19
TDS	340.7(129.3)	359.1(141.4)	294.0(58.7)	0.15
PH	7.44(0.54)	7.42(0.55)	7.53(0.47)	0.55
Chloride mg/l	6.88(4.65)	7.62(5.0)	6.39(3.57)	0.46
Conductivity EC ms/cm	0.47(0.18)	0.50(0.19)	0.39(0.08)	0.1
Al mg/l	0.01(0.015)	0.01(0.02)	0.01(0.02)	0.40
Cu mg/l	0.18(0.25)	0.23(0.3)	0.11(0.09)	0.2
Ca mg/l	106.6 (59.8)	110.2(69.6)	101.3(39.6)	0.7
Boron mg/l	0.11(0.03)	0.11(0.04)	0.11(0.03)	0.52
Alka-m	216.5(97.8))	223.2(104.5)	165.6(13.5)	0.04
Alka-P	11.8(8.2)	12.5(5.7)	10.7(4.2)	0.35
Carbonatealkalinity	22.4(12.5)	24.2(12.7)	19.6(11.6)	0.3
Bicarbonatealkalinity	194.1(100.6)	209.0(109.1)	146.0(19.9)	0.07
Temperature	19.3(1.2)	19.6(0.6)	18.2(1.7)	<0.001
MPN	2.85(1.62)	2.62(1.47)	3.27(1.79)	0.25

* two household samples are excluded because they come from same wells



Table (4): Classification of groundwater on the basis of salinity values [11]

TDS (ppm)	Description	No. of Samples
Less than 1000	Non-Saline	40
1000-3000	Slightly saline	0
3000-10000	Moderately saline	0
More than 10000	Very Saline	0
Total		40

Table (5): Classification of water on the basis of total hardness [12]

Total Hardness (mg/l)	Nature of water	No. of Samples
0-60	Soft	0
61-120	Moderate	0
121-180	Hard	0
More than 180	Very Hard	40
Total		40

4.DISCUSSION

In this study 27 samples from municipality wells and 13 samples from household tap water were collected and analyzed for physic-chemical and biological characteristics. One limitation of this study is that it was performed in one season however; the season of the study was in winter. There were no statistically significant differences between water samples from wells and households in terms of these parameters. pH indicates the intensity of acidic or basic character at a given temperature. pH is an important factor that determines the suitability of water for various purposes[13]and it is one of the most important operational water quality parameters. PH values higher than 8.5 are not suitable for effective disinfection while values less than 6.5 enhance corrosion in water mains and household. Therefore, the pH values for all well and house within



WHO limit except well 1 and 23 were (6.4), well 8 was (6.3). The low pH does not cause any harmful effect [14]. In groundwater hardness is mainly contributed by bicarbonates, carbonates, sulphates and chlorides of calcium and magnesium. The principal hardness causing ions are calcium and magnesium. The acceptable limit of total hardness is 100mg/l and maximum limit 500 mg/l was less than the WHO guideline value of 500 mg/L as CaCO₃ [15]. Durfor and Becker have classified water as given in Table (5) [11]. As per this classification 100% samples are very hard in nature. The level of hardness in present study was less than previse study in halabja [16] range (178.84 – 638.46 mg/l .The acceptable limit of carbonate and bicarbonate is 75 mg/l and 150 mg/l respectively. The maximum permissible limit of chloride in potable water is 200 mg/l. All the samples found chloride concentration within the permissible limit. No health based guideline is proposed by WHO for TDS. Since TDS higher than 500 mg/L impart taste to the water, therefore, a desirable value of 500 mg/L is proposed by (WHO). Furthermore, a value higher than 500 mg/L results in excessive scales in water pipes, heaters, boilers and household appliances [15]. TDS for well and house 3,6,7,8 and 12 were 529.5, 667.3, 681.8, 705.2 and 588.9 respectively and all the water samples are non-saline as per the salinity classification Table (4) suggested by Robinove [11]. Electrical conductivity is a measure of cations in water which can greatly affect its taste and thus has significant impact on the acceptability of water for drinking [17] and its suitability for irrigation. Higher value of conductivity shows higher concentration of dissolved ions .Electronic conductivity is a useful tools to assess the purity of water. The acceptable limits of Ca²⁺ 75 mg/l. 100% of water samples showed Ca²⁺ concentration above the acceptable limit.

5.CONCLUSION

In this study characterization of physicochemical parameters and biological test of twenty seven wells of groundwater and thirty house samples at Halabjacity area was carried out. To assess the quality of ground water and end point user each parameter was compared with the standard desirable limits prescribed by World health organization (WHO). From the study it can be concluded that groundwater is safe for drinking purposes from the point of view of level of pH



, Hardness , TDS , Ca , Boron , Alka-p , Alka-m, Al , Cu , Cl , conductivity and MPN. However biological surveillance is need especially in hot weather. But from the total hardness varies between 203-323 mg/l, which indicates that water in the deep aquifer is hard. Hence it is recommended that Halabjah water directorate take actions to soften the well water before consumption. Further research to carry out chemical and biological studies for existing water sources.

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AUTHOR



Faisal abdulla salih karim: BCS. General Chemistry / University of salahadin – Kurdistan 2004. MSC. Analytical chemistry/Pune University, India 2010, Specialist: Analytical chemistry. Assistant profess and director of heath and safety at Presidency of Sulaimani polytechnic university