Original Research Article

The Water Quality and Its Suitability for Various Uses at 16-Tishreen Dam Lake, Lattakia, Syria

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ABSTRACT

This study was conducted to evaluate the quality of water of “16-Tishreen Dam” Lake located in Lattakia Governorate. During two different periods in 2022, water samples were collected from ten points distributed across the entire lake. Samples were subjected to physical and chemical assessment using standardized procedures. The research revealed that the lake water is predominantly calcium, magnesium-bicarbonate-type water. Physicochemical parameters of the lake’s water quality were evaluated and compared to the Syrian Standards’ Specifications (2007). The samples taken were classified as fresh water suitable for drinking from a chemical point of view. The concentrations of cations and anions in the lake water were within the permissible limits set by national and global standards. Therefore, it was determined that the lake water is also suitable for irrigation of all types of crops.

Keywords: Major ions, Syrian standards specifications, drainage, groundwater

INTRODUCTION

Water resources are one of the most important natural resources in Syria, not only in terms of their vital importance, but also in terms of their role in the economy. Despite the abundance and availability of water resources relatively in Syrian coastal areas, they are subject to increasing demand due to intensive agricultural, tourism and industrial activities, in addition to the increase in population in coastal areas, which prompted the construction of many dams for collecting water in order to use it in irrigation operations, and as a source of drinking water , and since a large part of these dams are collecting dams, which makes them directly affected by the various pollutants that can reach them and its surrounding environment.
According to some studies conducted, the water in certain dams is considered to be of high purity. Therefore, from a chemical perspective, it is determined as a suitable water for drinking. However, there are other places that are not as pure and fail to meet the drinking water standards.
Other research was focused on determining the physical, chemical, and biochemical characteristics of the rivers that supply these dams, such as the Al-Kabir Al-Shamali River [1].

Numerous studies and scientific research have focused on the importance of water quality and its suitability for various uses [2,3,4,5,6], which were determined by a number of physicochemical analyses and the help of internationally approved charts.
Lake "16-Tishreen Dam" is located within the coastal basin in the northwest of the Syrian Arab Republic, about 11 km northeast of Lattakia Governorate. It passes through the Al-Kabir Al-Shamali River, which is located between two mountain masses of the Syrian coastal mountain ranges which are: the Syrian coastal chain from the south, and Al-Bayer and Al-Baseet massifs from the north and west, respectively.
The storage capacity of the lake is estimated at about (200-210) million cubic meters of water, and its water is used for irrigation of agricultural lands and for fish farming, the area of irrigation networks connected to the lake is estimated to be about 198,940 hectares. [8,7]
The search area is located within the following coordinates, Figure (1):
35° 41' 00" and 35° 37' 00" N: 36° 00' 00" and 35° 54' 00" E: .

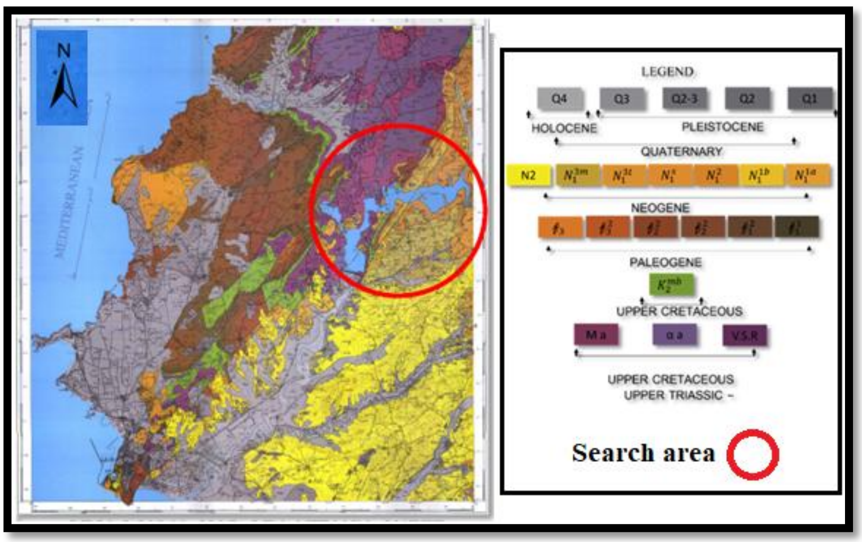

Figure (1) A geological map of Lattakia on a scale of 1/50000, including the research area [9] modified by the researcher.

The research area lies on a depression between two block layers, eastern and western. The eastern layer consists of clastic sediments from the Neogene period; where no faulty traces are observed, while small local silt traces appear. The western layer consists of calcareous and argillaceous deposits from the Maastricht and Paleogene periods that are layered deposits sometimes; as a result of erosion affecting the surrounding area and the ophiolite located north of the research area, which crosses a group of major and secondary faults and is distinguished from the eastern block by its topographical height, which then leads to the formation of Quaternary deposits consisting of sandy conglomerates in the region.
The region's climate is generally Mediterranean climate, where the temperature ranges between (10 C° to 29 C°), and it is characterized by high humidity throughout the year, as it ranges between (56% to 80%).

The following aquifers have been identified on the geological map, as well as in the explanatory note and complex geological formations of the area:

1- The Aquifer of the sedimentary-extrusive igneous (volcanic) rocks group: it is characterized by the abundance of springs flowing, but most of them have poor permeability.

2- The Aquifers of the higher Cretaceous and Paleogene rocks: They consist of chalky argillaceous calcareous rocks belonging to the Maastricht, which is non-water-bearing. The limestone layers belonging to the Middle Eocene are the main aquifer bearing water within the Paleogene layers.

3- The Aquifer of the Miocene rocks: it consists of sandstone, limestone, marl, and conglomerate, therefore it is considered an acceptable Aquifer.

4- The Aquifer of the Pliocene deposits: which are lenses of coarse or fine sandstone, and these deposits are poor in water-bearing in general.

5- The Aquifer of the Quaternary-fluvial deposits: These deposits are spread across river and valley beds, and they belong to the Holocene and Pleistocene periods. [9]

IMPORTANCE AND OBJECTIVE OF RESEARCH

The importance of the research lies in the fact that the waters of 16-Tishreen Dam Lake is an essential source for drinking and irrigation purposes, especially in the northern region of Lattakia Governorate, and based on that, this research aims to determine the quality of surface water, and its suitability for various purposes (drinking and irrigation).

METHODS

We collected ten water samples from different and distinct locations across the lake. Geological conditions and human activities in the area were take samples during two distinct periods of the year of (2022), the first period: on the 26th of February 2022 (the humid period) and the second period on the 3rd of August 2022 (the dry period).

Water samples were then analyzed in the laboratories of the Directorate of Water Resources in Lattakia, and the laboratories of the Faculty of Science at the University of Damascus, at the best conditions possible. The following points have been considered in order to ensure a perfect analysis, first of all the amount of sample is sufficient for carrying out laboratory procedures and samples must be stored under identical conditions as those during collection; lastly, none shall be subjected to any exposure. pollutants that may alter their properties starting from the time collection till the time of testing.

The research determined the concentrations of the main ions (cations and anions), and identified by the following materials: (bicarbonate, sulfate, chlorine, sodium, potassium, calcium, and magnesium).

RESULTS AND DISCUSSION

The following results shown in Table (1) were obtained by processing the results of chemical analyses of the collected water samples distributed across the research area shown in Figure (2) as follows: Recalculating results by converting the ionic weight from (ppm) to the equivalent form (epm), and to the relative equivalent form (epm%).

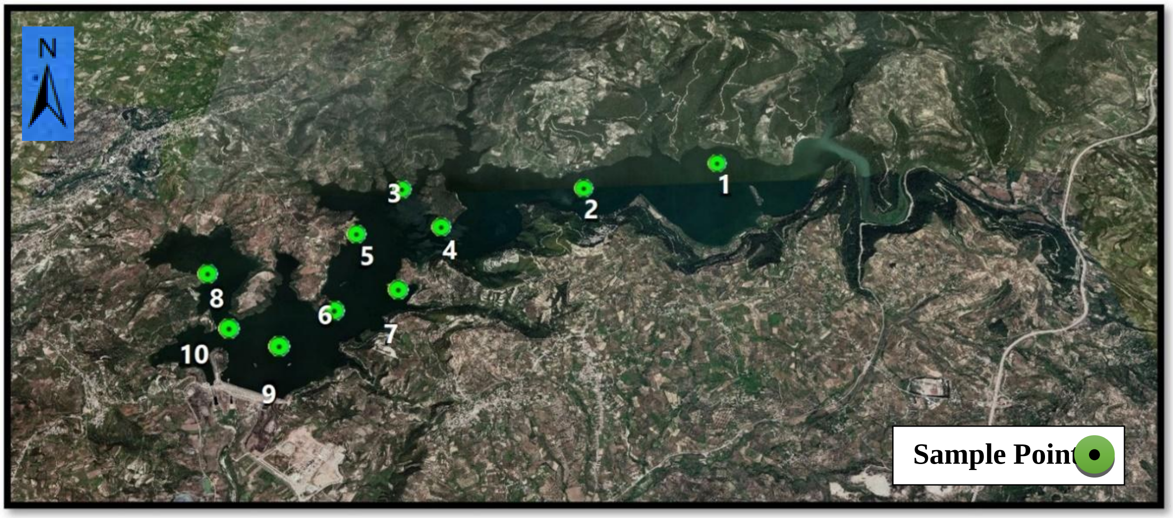

Figure (2) A satellite image from (Google Earth) showing the locations where water samples were collected from the 16-Tishreen Dam Lake

Table (1) average results of the analyses that we carried out and the " Kurolov –Formula" with its relationship to surface water samples

Sampling Point	Unit	Positively charged ions (Cations)				Negatively charged ions (Anions)			Kurolov –Formula
		Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	HCO_3^{-}	SO_4^{2-}	Cl^{-}	
1	ppm	14	2.56	29.3	15.244	236.375	59.5	34.05	$M0.588 \frac{Hco3\ 63.79\ So4\ 20.40\ Cl\ 15.79}{Ca\ 43.16\ Mg\ 36.96\ Na\ 17.93} pH\ 8.27$
	epm	0.60	0.06	1.46	1.25	3.87	1.23	0.95	
	epm%	17.93	1.93	43.16	36.96	63.79	20.40	15.79	
2	ppm	16.03	3.03	37.16	16.10	259.25	57.5	35.52	$M0.557 \frac{Hco3\ 65.90\ So4\ 18.57\ Cl\ 15.51}{Ca\ 46.93\ Mg\ 33.48\ Na\ 17.61} pH\ 8.31$
	epm	0.69	0.07	1.85	1.32	4.25	1.19	1.00	
	epm%	17.61	1.96	46.93	33.48	65.90	18.57	15.51	
3	ppm	17.16	3.08	47.8	14.83	202.06	54	35.31	$M0.548 \frac{Hco3\ 60.97\ So4\ 20.71\ Cl\ 18.31}{Ca\ 53.87Mg\ 27.5\ Na\ 16.82} pH\ 8.30$
	epm	0.74	0.07	2.39	1.22	3.31	1.12	0.99	
	epm%	16.82	1.78	53.87	27.5	60.97	20.71	18.31	
4	ppm	10.68	2.36	31.6	14.87	228.75	59.5	33.00	$M0.542 \frac{Hco3\ 63.35\ So4\ 20.94\ Cl\ 15.70}{Ca\ 47.46\ Mg\ 36.76\ Na\ 13.95} pH\ 8.33$
	epm	0.46	0.06	1.58	1.2	3.75	1.23	0.92	
	epm%	13.95	1.82	47.46	36.76	63.35	20.94	15.70	
5	ppm	19.11	4.06	58.4	15.09	228.75	59.5	36.41	$M0.537 \frac{Hco3\ 62.34\ So4\ 20.60\ Cl\ 17.05}{Ca\ 57.28\ Mg\ 24.36\ Na\ 16.30} pH\ 8.09$
	epm	0.83	0.10	2.92	1.24	3.75	1.23	1.02	
	epm%	16.30	2.04	57.28	24.36	62.34	20.60	17.05	
6	ppm	6.32	1.35	57.4	16.25	183	58.5	30.85	$M0.537 \frac{Hco3\ 58.96\ So4\ 23.95\ Cl\ 17.08}{Ca\ 63.53\ Mg\ 29.60} pH\ 8.29$
	epm	0.27	0.03	2.87	1.33	3	1.21	0.86	
	epm%	6.08	0.76	63.53	29.60	58.96	23.95	17.08	
7	ppm	11.28	3.395	49.8	13.71	167.75	60	33.53	$M0.537 \frac{Hco3\ 55.61\ So4\ 25.28\ Cl\ 19.10}{Ca\ 59.34\ Mg\ 26.89\ Na\ 11.68} pH\ 8.27$
	epm	0.49	0.087	2.49	1.12	2.75	1.25	0.94	
	epm%	11.68	2.07	59.34	26.89	55.61	25.28	19.10	
8	ppm	28.35	4.39	66	14.95	244	56.5	41.13	$M0.528 \frac{Hco3\ 63.13\ So4\ 18.57\ Cl\ 18.28}{Ca\ 56.16\ Mg\ 20.97\ Na\ 20.97} pH\ 8.30$
	epm	1.23	0.11	3.3	1.23	4	1.17	1.15	
	epm%	20.97	1.91	56.16	20.94	63.13	18.57	18.28	
9	ppm	37.985	4.68	56.2	11.3	205.875	54.5	45.25	$M0.531 \frac{Hco3\ 58.33\ So4\ 19.62\ Cl\ 22.03}{Ca\ 50.98\ Mg\ 16.87\ Na\ 29.96} pH\ 8.31$
	epm	1.65	0.12	2.81	0.93	3.37	1.13	1.27	
	epm%	29.96	2.17	50.98	16.87	58.33	19.62	22.03	
10	ppm	22.02	3.32	57.4	14.46	190.62	55	37.98	$M0.527 \frac{Hco3\ 58.51\ So4\ 21.45\ Cl\ 120.03}{Ca\ 56.24\ Mg\ 23.32\ Na\ 18.76} pH\ 8.33$
	epm	0.95	0.08	2.87	1.19	3.12	1.14	1.06	
	epm%	18.76	1.66	56.24	23.32	58.51	21.45	20.03	

Surface water quality according to the "Kurolov –Formula"

By applying the Kurolov-Formula with adopting the most widely accepted and used classification [10], which divides the hydrochemical facies (types) according to the dominant negative anion, the following facies were distinguished:

- Calcareous-magnesia-bicarbonate facies in the following samples (1-2-3-4-6).
- Calcareous-magnesia-bicarbonate-sulphate facies in sample No. (7).
- Calcareous-bicarbonate facies in the following samples (5-8-9-10).

Determining the suitability of water for different uses

The water is to be considered polluted when the concentration of one of the pollution indicators exceeds the permissible limit, but the level of the indicator may sometimes increase far beyond this limit where the problem here becomes more complex. Therefore, the state of water quality was evaluated from a chemical point of view based on the detailed study given by the Syrian standards adopted in evaluating the quality and suitability of this water for drinking and irrigation purposes [11].

Suitability of Drinking water

All analysis results for the pH values and the main electrolytes (Na+, Ca2+, Mg2+, K+, HCO3-, SO42-, Cl-) for the collected water samples came within the permissible limit for drinking water according to the Syrian standard specification of drinking water, table (2).

Table (2) The rates adopted in Syrian Arab Republic for evaluating the suitability of drinking water [11]

Permissible Limit According to the Syrian standard specification (2007)	Unit	Symbol	Component
9 – 6.5	-	pH	Acidity/Basicity Scale
200	mg/l	Na+	Sodium
200		Ca2+	Calcium
150		Mg2+	Magnesium
10		K+	Potassium
500		HCO3-	Bicarbonate
250		SO42-	Sulfites
250		Cl-	Chlorine

Suitability of water for Irrigation purposes

The quality of water for irrigation purposes is evaluated through several internationally adopted standards, which are:

Total dissolved salts (TDS).

An increase in salinity of irrigation water leads to an increase in soil salinity, and this causes problems in plant growth and productivity. Food and Agriculture Organization "FAO" [12] has set classification standards for water used in irrigation according to its degree of salinity, as shown in Table (3)

Table (3) Classification of water used for irrigation according to its degree of salinity as given by the Food and Agriculture Organization (FAO)

Water Quality and Degree of problem	TDS mg/L
Water with good characteristics and does not cause any problems if used	450<
The use of this water involves some increasing problems	2000 – 450
The use of this water causes severe problems	2000>

According to Table (1) results showed, that the salinity values of each of the samples of the selected sites ranged between (527 - 588) mg / L. Therefore, the use of these samples can cause some increasing problems. In general, the water can be considered suitable for irrigation and for all agricultural crops; as the salinity values in most analyzed samples did not reach 2000 mg / L [12].

Sodium percentage (Na)%

Sodium plays a major role in determining the suitability of irrigation water, and therefore the percentage of sodium ion is one of the most important characteristics that plays a key role in evaluating the quality of irrigation water. Which can be determined by the following equation [13]:

$$Na\% = \frac{Na \;\; or \;\; (Na+K)}{Ca+Mg+Na+K} \times 100$$

The following classification was given to the quality of irrigation water according to Sodium percentage, as shown in Table (4):

Table (4) Classification of water used for irrigation according to the percentage of sodium [13]

Water Quality and Degree of Suitability	Na%
Excellent	20 %<
Accepted (Permissible)	60 – 40 %
Results are not guaranteed (Doubtful)	80 – 60 %
Unsuitable	80 % >

Sodium values ranged between (6.08 - 29.96%), and therefore they range from “excellent” to “acceptable” for irrigation purposes, according to Table.(4)

This percentage was also represented for the studied samples on the "Wilcox,s" chart, which is a graphical chart in which the Sum of Cations in the equivalent form (epm) is displayed on the X-axis, and on the samples axis is Sodium Percentage (Na)%, and this chart is divided into regions according to the properties of the water. Figure (3).

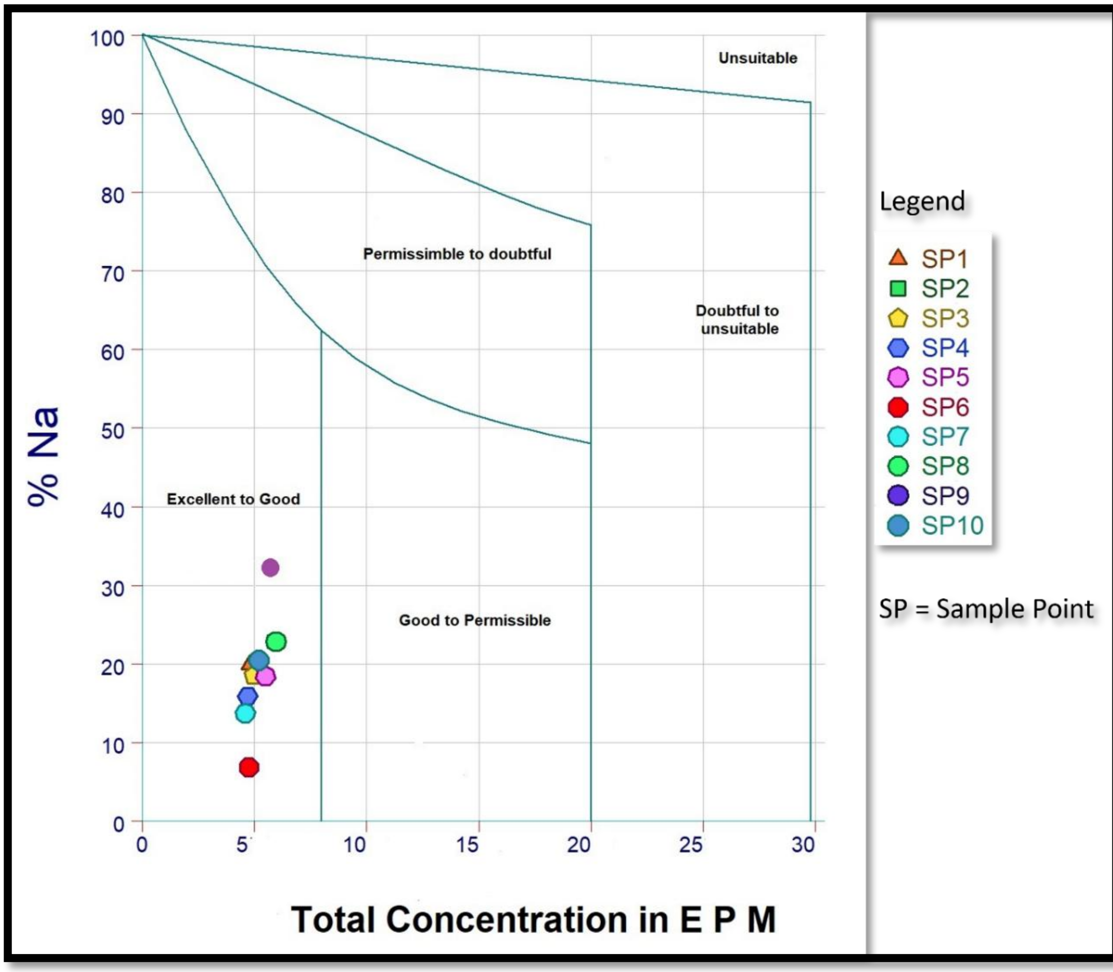

Figure 3: Wilcox's diagram and the locations of aqueous samples within it

All samples came within Wilcox’s diagram between the “good” to “excellent” for Irrigation range.

Sodium Absorption Rate (SAR)

Sodium is considered one of the most dangerous elements present in irrigation water, as it affects the physical properties of the soil by breaking up its granules, which turns it into soil with poor permeability, affecting growth of plants negatively. It also negatively affects sensitive plants due to its toxic accumulation in the leaves of these plants. According to the American Classification of Salinity Laboratory, the danger of sodium in irrigation water is determined by estimating the ratio of sodium to each of calcium and magnesium respectively, as given in the following formula [14]:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Ionic concentrations are expressed in (epm), where the water is classified into four types by SAR ratio according to its suitability for irrigation, as shown in Table (5).

Table(5) Classification of water used for irrigation according to the sodium adsorption rate [14]

Use	Na+ Content	SAR	Pattern
Can be used for all types of soil	Low	0 - 10	1
Better be used with coarse textured soil or good permeability soil	Medium	10 - 18	2
May cause harmful effects	High	18 - 26	3
Unsuitable for agricultural purposes	Very High	- 100 26	4

By applying the above-mentioned formula for calculating SAR depending on the results of the chemical analyses processed in Table (1), we obtained the values of the sodium adsorption ratio (SAR) in the water samples collected from the research area, as shown in Table (6):

Table (6) Sodium Absorption Rate values in each collected samples

Location	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10
SAR	0.521	0.552	0.555	0.392	0.576	0.189	0.364	0.818	1.207	0.672

The water in the research area is classified according to the results of Table (6), and based on the classification adopted in Table (5) which indicates that having a sodium adsorption ratio ranging between (0 - 10) (low sodium content) makes the water suitable for irrigation for all soils as shown by the analyzed water samples collected from the area which have sodium absorption rates ranging between (0.189 - 1.207).

CONCLUSIONS AND RECOMMENDATIONS

The water in "16-Tishreen Dam" lake is predominantly calcium, magnesium-bicarbonate type water.
The results of the chemical analyses performed on all samples taken indicated that water is suitable for drinking and irrigation purposes, in accordance with the standards set by Syria's national standard specifications as well as internationally accepted standards.
In view of these considerations, we recommend the following:

- Ensuring that water is of suitable quality for a variety of uses, as well as monitoring the changes in this quality over time, establishing a regularly monitored network to assess water quality by performing all types of physicochemical and microbiological analyses.
- Conducting periodic analyses of each of the minor, rare and toxic elements of the research area water.
- Developing and implementing a model of the water quality monitoring system, taking into account hydrological conditions in the research area, similar to that employed in other countries including: (Canadian index, Malaysian index, etc.)

REFERENCES

[1] Tamim Alia, & Lina Salameh. (2013). A study of some chemical indicators of the water quality of dams in Lattakia Governorate. Tishreen University Journal - Engineering Science Series, 35 (2).

[2] Groundwater geochemistry of the Yucatan Peninsula, Mexico. Journal of Hydrology, 2009.

[3] ALSANJARI, A.; ALQATTAN, A. Water Quality Assessment, and Suitability for Irrigation Purposes of Lesser Zab River, Northern Iraq. Iraq Journal of Sciences, Vol. 56, No. 3, 2015, 2187 – 2199.

[4] DALELA, Z.; BOUDAOKHA, A.; ALHASAN, B. Assessment of water quality for drinking and irrigation using principal ion chemistry in the semi-arid region. Asian Journal of Geosciences, 2017.

[5] Yasser Al-Mohammad, Sharif Hayek, Darin Bourjeh. (2014). Hydrochemical study of the free groundwater in a part of Damascus's Ghouta. ALBaath University.

[6] Ibrahim, A.; Raee, K. Assessment of groundwater quality in some selected wells within Lattakia Governorate and its suitability for drinking and irrigation. Syria. Tishreen University Journal for Research and Scientific Studies of, Vol. 43, No. 6, 2021, 17.

[7] Manna, Ranim. (2013). Study of the water quality of the 16th of October Dam Lake . Master thesis, supervised by Dr. Haitham Janad, Dr. Kawkab Harba. Faculty of Civil Engineering, Environmental Engineering major, Tishreen University, Syria.

[8] Syria. Water Resources Archive - Lattakia Branch.

[9] ADJEMIAN, J.; KHATOUN, A. The Geological Map of Syria Scale 1:50000 of Lattakia sheets NI 36 - XVI - E - b, Ministry of Petroleum and Mineral Resources. 1999.

[10] BITIVA, K. A. The Hydrogeocheimstry, The Chemical composition of groundwater. Moscow, 1978, 328.

[11] The Syrian Arab Standards and Metrology Organization. Syrian Standard Specification Book for drinking water No. 45. Ministry of Industry, Damascus, 2007.

[12] AYERS, R.S. and D.W. WESTCOT. Water quality for agriculture FAO irrigation and drainage paper No 29. FAO publications. Rome .Italy, 1976, 107.

[13] WILCOX, L.V. Classification and use of irrigation water. U.S. Dep. Agriculture. Circ. Washington D.C., 1955, 969.

[14] TODD, D.K. and MAYS, L.W. Ground water Hydrology. 3rd. ed., John Willey & Sons Inc, USA, 2005, 636