 https://doi.org/10.1051/e3sconf/202342704010

Assessments and Historical Changes the Water Quality of Sawa Lake, Southern Iraq for the Period 1977-2020

Nawar O. Al-Musawi[1, a *] and Ahmed M. Al-Sulaiman[2, b]

[1]Civil Engineering Department, University of Baghdad, Baghdad, Iraq.

[2]Civil Engineering Department, University of Al-Qadisiyah, Al-Qadisiyah, Iraq.

[a]Nawar.o@coeng.uobaghdad.edu.iq and [b]ahmed.jabbar@qu.edu.iq

*Corresponding author

Abstract. This investigation pertains to the evaluation of water quality in SAWA Lake, located in the Al-Muthanna province of Southern Iraq, from 1977 to 2020. Understanding the water quality and assessments of this Lake is of great importance. The Lake is home to small, transparent, blind fish measuring approximately 10 cm and is often referred to as the "wonderful" or "strange" Lake due to its many unique features. The study focuses on several elements to represent water quality, including total dissolved solids (TDS), electrical conductivity (EC), pH, and temperature (T), which were measured directly in the field. Additionally, scientific concepts such as K^+, Ca^{2+}, Cl^-, HCO_3, and KSO_4 were used in each sample. Scientists have analyzed the density and salinity of the lake water and found that its water density exceeds that of seawater, and its salinity exceeds that of the Gulf of Arabia by about 1.5 times. The water is salty, surrounded by natural lime, and is automatically renewed by nature when it is broken. Its hardness also characterizes it, and its water volume fluctuates depending on the wet and dry seasons. The Lake is roughly 4.74 km in length, and all the elements under study showed an increase in concentration during the periods of 1977, 1983, and 2003 with $NaSO_4$, which later changed to MgCl between 2007 and 2011. The study found that Sawa Lake water was unsuitable for drinking or irrigation purposes between 2016 and 2020 due to the increased concentration of certain elements. This increase in concentration is attributed to the Lake's location, nutrition, and the lack of rain, which means it relies solely on groundwater.

Keywords: Sawa lake; water quality; salinity; TDS.

1. INTRODUCTION

Sawa Lake can be found within the Muthanna Governorate in the southern part of the Iraqi Republic, close to the Euphrates River. The Lake is situated approximately 23 kilometers away from the city of Samawah. This body of water is unique in Iraq due to its high salinity levels and is surrounded by natural lime. Sawa Lake is a mix-mesohaline water body with no inflow or outflow, and its hardness allows it to renew itself naturally when broken [1]. The "wonderful" or "strange" Lake, located between longitudes (44 59 29.01E and 45 01 46.61E) and latitudes (31 17 43.10N and 31 19 49.79N), is home to small, approximately 10-centimeter-long fish that are unique in their lack of sight and transparent appearance. This body of water is sometimes referred to as the "wonderful lake" due to its numerous marvels, including these fish, or the "strange lake" due to its peculiarity. Situated roughly 23 kilometers to the west of Al-Samawa city is Swan Lake [2].

The lake water density and salinity have been examined by scientists, revealing that it has a higher density than seawater and a salinity level one and a half times greater than that of the Arabian Gulf. The percentage of water on the earth's surface varies, rising and falling during wet and dry seasons. The Lake is approximately 4.74 km in length and 1.77 km in width, with a limestone wall thickness of about 12 km. The flat terrain inclines more sharply towards the southeast at a rate of 2.7 meters per kilometer and boasts natural phenomena like sand dunes and sabkha. The Lake's water is prevented from escaping to the ground by naturally formed salt walls, some stretching six meters long, taking on unusual shapes and sculptural forms reminiscent of cauliflower, as shown in Figure 1.

Figure 1: These salt walls are formed in strange shapes and artistic sculptures resembling cauliflower.

https://doi.org/10.1051/e3sconf/202342704010

2. STUDY AREA

The Lake is situated southwest of Samawah, approximately 25 to 30 kilometers away. The study area is astronomically limited between latitudes 31.7 to 31.20 in the north and longitudes 44.59 to 45.11 in the east. The Lake's shape is irregularly oval and resembles the fruit of a pear. It stands at an elevation of 18 to 20 meters above sea level and is around 6 meters higher than the surrounding lands. This research identifies the Lake's age, explains the origin of its name, and refutes several associated studies, dismissing them as unrealistic and unscientific [3]. During the period from 1990 to 2011, climatologic data was gathered from a meteorological station in Samawa, revealing that the investigated region experiences an arid climate. The temperature range fluctuates between 27.6 to 44.6 degrees Celsius for both the highest minimum and maximum temperatures. Additionally, the mean annual rainfall in the area is approximately 110 mm, while the highest evaporation rate occurs in July (506 mm) and the lowest in January (89 mm). The predominant wind direction in the region is N-W, with speeds of 4.1 m/s, and it blows for most of the year during the same period [4].

3. GEOLOGICAL LAKE

Initially, the Lake was created by merging three separate bodies of water, each with its own natural barrier. Over time, these lakes underwent geomorphological processes that caused them to combine and form one larger body of water known as Sawa Lake. This can be observed through the recording of three distinct depths, which are shown in four stages in Figure 2. Sawa Lake receives its water from cracks, fractures, and faults that slope towards it from the aquifer basin of the Shabka-Salman range. This range covers an area of up to 20,000 km2 and is supplemented by the Dammam basin in Saudi territory. These basins have ample water levels and high flow rates, Figure 2.

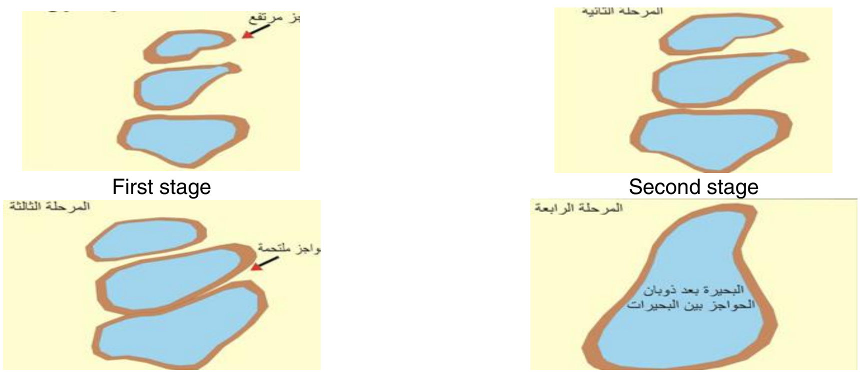

Figure 2: Considering it a form of imagination and an absurd and unscientific perception of historical change for the lake surface through four stages.

4. FIELDWORK AND METHODS TO OBTAINED PURPOSE OF STUDY

In Iraq, field and laboratory tasks are performed to comprehensively analyze physical, chemical, and biological features. Between 2016 and 2020, eleven samples were gathered from the Lake's edge using one-liter polyethylene bottles for physical and chemical assessments. To prevent contamination of the samples, all the equipment utilized for sample collection, storage, and chemical analysis underwent a thorough cleaning process using deionized water. These cleaning and storage procedures guarantee that the sampling equipment is free from any detectable impurities [5]. The Service Laboratory in Civil Engineering at the University of Baghdad analyzed water samples from Sawa Lake using various techniques. Cations K^+ and Ca^{2+} were determined using atomic absorption spectrometry, while anions Cl- were assessed via titration. In addition to these laboratory analyses, several parameters, such as temperature, pH value, electrical conductivity (EC), total dissolved solids (TDS), and bicarbonate [HCO_3], were measured locally in the field. By identifying and highlighting the issue, efforts were made to find a solution and reduce the potential risks associated with the problem.

4.1 Describe Water Quality in Lake

Sawa Lake is a land-locked Lake; it has no beach lying within Iraq's (stable shelf) [6]. It has a salt rim formed from a gypsum barrier that rises between (3-6) m above the land and surface water [7]. The gypsum barrier prevents the surface water from entering the Lake. It elevated above the sea water about 18.5 m [7 and 8]. Sawa Lake elevates above the surrounding land by about (1-4) m and (5-7) m above the Euphrates River.

The study extended for a period of 43 years, from 1977 to 2020. According to data collected from researcher's works [4,8,12,14]. Measuring the lake water levels (piezometers located on the eastern and southern sides of Sawa Lake for a period of years, according to the study conducted by researcher Hussein Qassem [2].

4.2 Electrical Conductivity [EC]

The similarity in the electrical conductivity levels between the lake bottom water and the salinity levels of nearby wells suggests a shared source of water supply between the wells and the Lake. This contrasts with the higher electrical conductivity values observed in the lake surface water, where the higher salinity in the lake bottom water may be due to the mixing process. The water at the highest layer with high salinity in the Lake exhibited similar electrical conductivity values to those of water springs located in a straight line with decimal values, indicating a correlation between the feeding springs of Lake Sawa with values ranging from 0.1 to 8.3 relative to the values of the lake bottom water. On the other hand, no significant relationship was found between the lake surface water components and the water springs.

4.3 Degree of Interaction [pH]

The degree of water interaction at the lake surface has a yearly average ranging from 2.8 to 2.52, indicating highly alkaline water. This can be attributed to the high concentration of carbonates in the surface water layer, with levels ranging from 21.2 mg/L to 135.8 mg/L dissolved in water (DO). Biological activity and lichens consumption contribute to a decrease in these values. The degree of water interaction in the lake bottom water was found to be 7.2, while in the observation wells, it ranged from 7.1 to 2.8, and in the water springs, it ranged from 7.80 to 2.1. All of these values were lower than the average value observed in the surface layer of the lake water.

4.4 Total Dissolved Solids (TDS)

Salts of calcium, magnesium, sodium, and potassium in the irrigation water may be injurious to plants. When present in excessive quantities, they reduce the osmotic activities of the plants and may prevent adequate aeration [9]. The TDS value of the study area is 21543 ppm for the dry period. Based on TDS, the water of Sawa Lake can be classified as brackish water according to references [10-11]. The water of Sawa Lake is classified as unsuitable for irrigation use.

4.5 Potassium [K]

The potassium content in the Lake's surface water ranged from 170.0 to 110 mg/L, with an annual average of 831.32 mg/L. In contrast, the value for the sample collected at a depth of 10 m was 105.07 mg/L, indicating a higher concentration of potassium in the upper layer of the lake water. The elevated levels of potassium in the upper layer can be attributed to the dissolution of minerals that contain potassium and the rapid movement of water at the bottom of the Lake through faults, stream springs, and clouds. Other formations on the western side of the Lake may also contribute to these processes [13].

4.6 Bicarbonate [HCO_3]

The bicarbonate levels in the lake surface water ranged from 105.33 mg/L to 302.72 mg/L, with an annual average of 182.20 mg/L. These values are relatively similar to the bicarbonate values observed at the lake bottom, which were measured at 500.55 mg/L. The primary source of bicarbonate ions in groundwater is the pH level, which can be influenced by the dissolution of carbonate rocks and the types of dissolved carbonates present in the water, as they contribute to the total basicity observed at 8 o'clock [11].

5. RESULTS AND DISCUSSION

This section covers the study period for the Lake, which was chosen to span from 1977 to 2020. The following elements were selected for analysis during this time period: pH, electrical conductivity (EC), total dissolved solids (TDS), calcium (Ca), potassium sulfate (KSO_4), chloride (Cl), and bicarbonate (HCO_3). The time period from 1977 to 2011 represents a pre-study period, where the results of previous research have been compiled. The study has been extended beyond this period to include 2012, 2015, and 2020, comparing the results obtained against the maximum permissible limits outlined in the Iraqi specification shown in Table 1. It was possible to complete the study period for the elements of the Lake. Still, it was sufficient these years because of the difficult period that the country was going through due to demonstrations and difficult security conditions.

Figure 3 represents the change in the values of the degree of reaction for different periods from 1977 to 2020. The figure shows that the pH values do not exceed or close to the limits permitted within the Iraqi specification. This is due to the water supplying the Lake, which is groundwater. The eyes close to it. It is worth mentioning here that the permissible value or limits.

Table 1: Data collected from other researchers' previous works [4,8,12,14].

Parameters	1977	1983	2003	2007	2011	2012	2016	2020	Max. Permissible*
pH	-----	-----	8.8	8.9	8.58	8.45	8.58	8.58	6.5-8.5
EC	-----	-----	31000	18700	32.16	23.15	32.88	31.57	2000
TDS	18920	18824	29440	17771	1701	27080	17016	1701	1000
Ca	1060	950	884	1700	1699	1478.3	1699	1698	200
Mg	1028	1042	1630	2936	972.3	1875.4	972.3	972.5	150
Na	3220	3086	6481	1571	6413	2266	6413	6329	50
K	112	195	152	275	164.5	241.2	243	241.1	10
SO_4	6432	5571	9777	4271	5990	3483	3484	5990	400
Cl	5148	5406	7968	6925	64173	8003	8008	64173	250
HCO_3	120	87	193	203	179.3	203	198	200	----

* Maximum permissible limits according to modified Iraqi specification 2009.

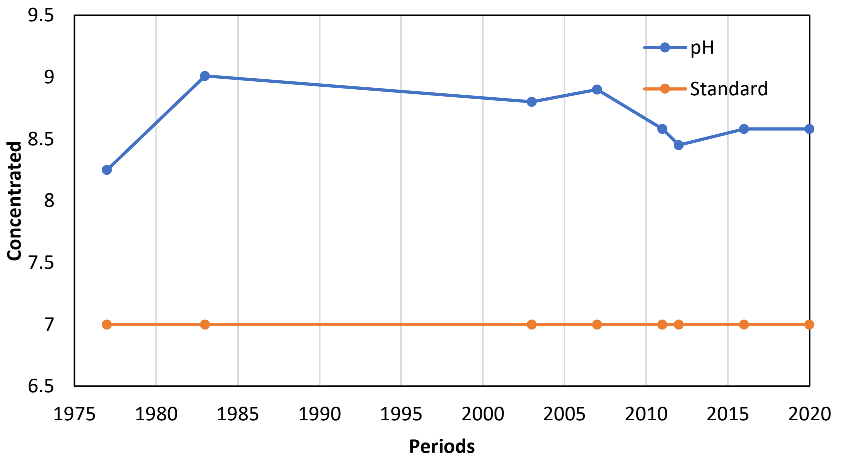

Figure 3: Variation of pH with time.

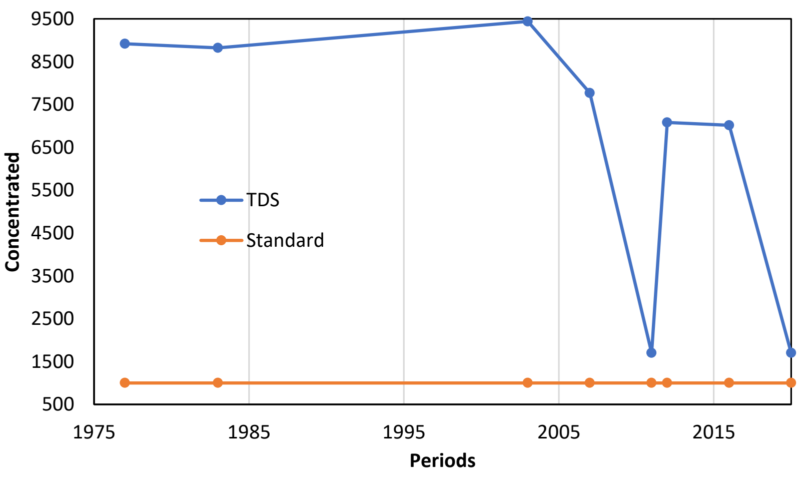

Figure 4: Variation of TDS with time.

When looking at Figures 4 and 5, which represent the concentrations of each of total dissolved salts (TDS) and electrical conductivity (EC), we can clearly see that the curves representing the permissible cumulative concentration of (EC) and (TDS) are away from the Standard Line For these elements, due to the increase in the concentrations of these elements over the time periods this studied. The increase in these concentrations is due to the location of the lake unit's nutrition.

 https://doi.org/10.1051/e3sconf/202342704010

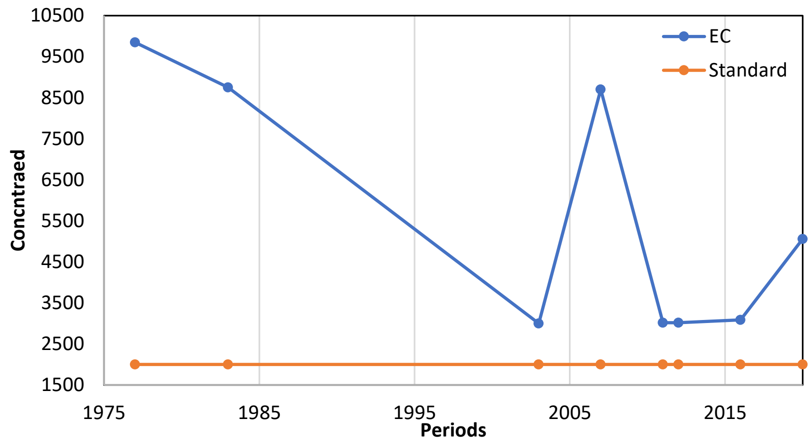

Figure 5: Variation of EC with time.

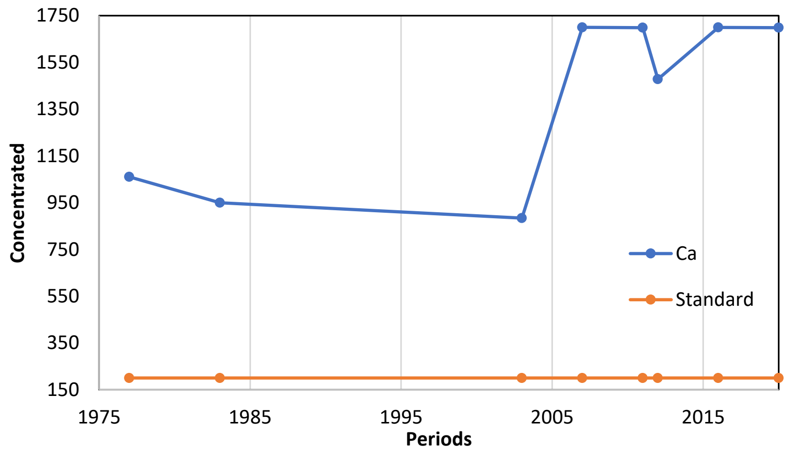

Figure 6: Variation of calcium over time.

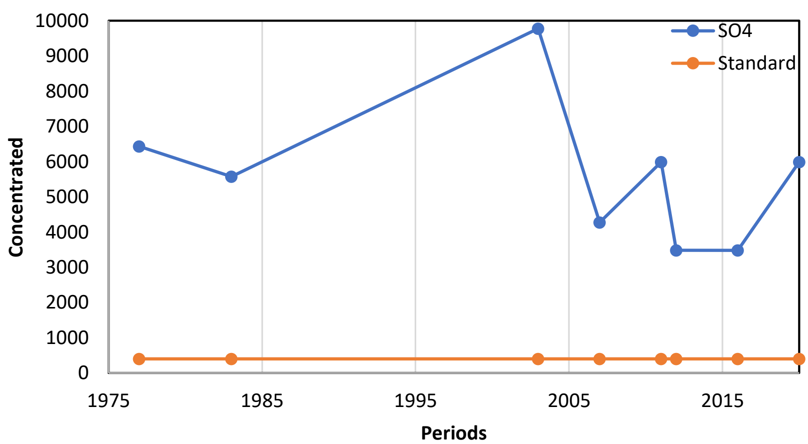

Figure 7: Variation of sulfate within the time.

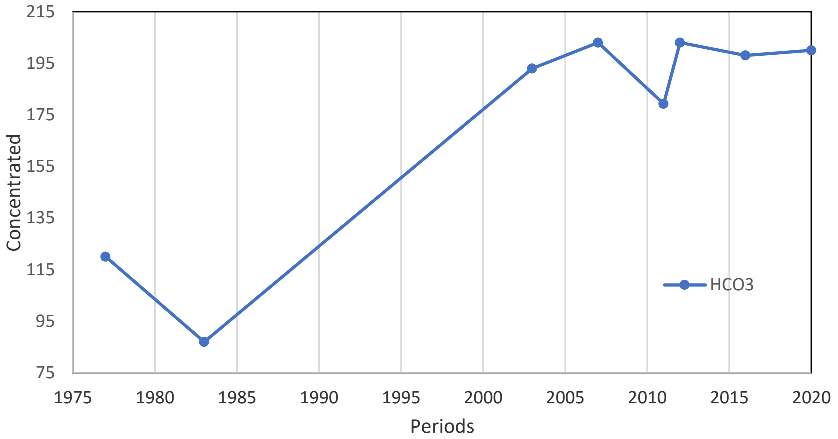

Figure 8: Variation of bicarbonate with time.

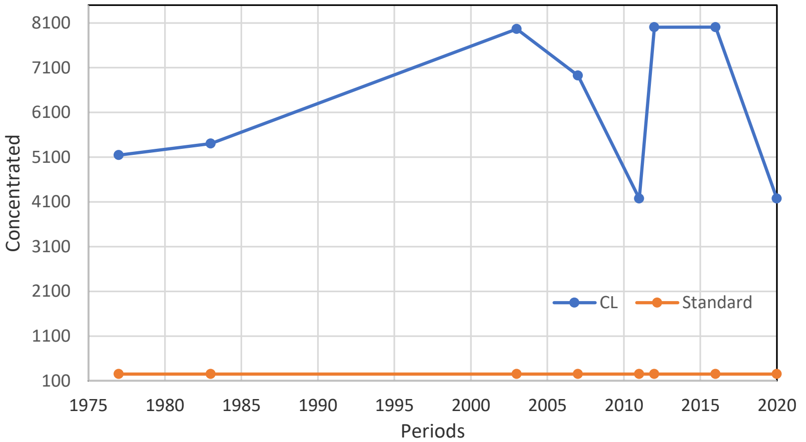

Figure 9: Variation of chloride with time.

Figures 6 to 9 depict the concentrations of Ca, KSO_4, HCO_3, and Cl in the Lake, respectively. These elements show a convergence of values, and the distance between the lines representing their concentrations is clearly visible. However, the Lake's concentrations of these elements are below the standard line due to its high salinity, which is attributed to its source of groundwater and adjacent springs, as well as the low rainfall and high temperatures in the area. The high concentration of Ca in the study area is attributed to the water flow from rocks containing lime, gypsum, and hydrated gypsum, as well as the water temperature effect. When looking at Figures 4, 5, and 7, which represent the concentrations of each of TDS, EC, and HSO_4, we can clearly see the deviation of the curves that represent the permissible cumulative concentration of (TDS), (EC), and (HSO_4) about the Standard Line for these elements, due to the increase in the concentrations of these elements during the studied time periods from 1977 to 2020. The reason for the increase in these concentrations is due to the location of the Lake and its nutrition. There was no rain. It depends on groundwater only. Figures 8 and 9 show high concentrations of each bicarbonate and chloride because of the nature of lake rocks.

6. CONCLUSIONS

The increase in these concentrations is due to the location of the lake unit's nutrition. The Lake is less than the standard line because the Lake has high salinity, and this is due to the source from which the lake feeds, as it feeds on groundwater and the springs adjacent to it and because of the lack of rain that feeds the area and the high temperatures as well. In addition, the high concentration of calcium ion (Ca) in the study area is due to the flow of water from rocks rich in lime, gypsum, and hydrated gypsum, as well as the effect of water temperature.

Water supply to the Lake and the presence of groundwater contribute to reducing concentrations for some parameters in the Lake.

REFERENCES

[1] Jamil AK. Geological and hydrochemical aspects of Sawa Lake- S. Iraq. Bull. Coll. Sci. 1977; 18(1):221-253.
[2] Hussein HQA. Fluctuation of water levels and quality of Sawa Lake and its relationship to groundwater and surrounding lands. M.Sc. thesis, Al-Muthanna University. 2018.
[3] Al-Shemari AN. Hydrogeology and hydrochemistry of Rehab area/South and South West of Samawa City. M.Sc. thesis, University of Baghdad. 2006.
[4] Al-Basrawi NH. Hydrogeology and hydrochemistry of Lake Sawa [research published on the Geological Survey website]. ar/mee/index.com.
[5] Shafer M, Overdier J, Hurley J, Armstrong D, Webb D. The influence of dissolved organic carbon, suspended particulates, and hydrology on the concentration, partitioning and variability psoriatic arthritis and concomitant fibromyalgia. IMAJ3. 1997; 147–150.
[6] Buday T. The regional geology of Iraq. GEOSURV, manuscript report. 1973.
[7] AWADH, S. M.; MUSLIM, R. E. Sawa Lake: The Nature and Unique. Characteristics. In: Proceeding of the Second Scientific Symposium, Natural Heritage. Research Center and the Museum of Natural History. 2006.
[8] Al-Naqash AB. Hydrogeological and hydrochemical sediment petrographical study of Sawa Lake. Bull. Coll. Sci. 1977; 18(1):199-220.
[9] ROBINOVE, Charles Joseph; LANGFORD, Russell Hal; BROOKHART, Joseph W. Saline-water resources of North Dakota. US Government Printing Office. 1958.
[10] ALTOVISKI, M. E. Hand book of hydrogeology. Geogoelitzet, Moscow, USSR (In Russian). 1962.
[11] Todd DK. Groundwater hydrology. 2nd ed. John Wiley and Sous, Third Reprint, Inc., India. 2007.
[12] Al-Jawad AA, Al-Sha'a SA, Al-Miqdadi S. A hydrological and tectonic comparison of Sawa Lake. Fifteenth Iraqi Geological Conference, Geologists Syndicate, Baghdad, Iraq. 2015.
[13] Alwadh S, Muslem R. The formation models of gypsum barrier, chemical temporal changes and assessment of water quality of Sawa Lake at southern Iraq. M.Sc. thesis, University of Baghdad. 2014.
[14] Albadia Research Center, 2020, documented data.