REVIEW OF INTERNATIONAL GEOGRAPHICAL EDUCATION

ISSN: 2146-0353 ● © RIGEO ● 11(5), SPRING, 2021

www.rigeo.org

Research Article

Evaluating the Climatic Change Effect on the water Quality of Euphrates River from Haditha to Al-Hindiya/ Iraq

Iman A. Al- Ali[1]
Geology Department, College of Science, University of Baghdad, Iraq
emanahmedmohammedali2003@gmail.com

Mutaz A. Al- Dabbas[2]
Geology Department, College of Science, University of Baghdad, Iraq
profaldabbas@yahoo.com

Abstract

Recently, Iraq's rivers are suffering from extreme shortage in water due to the climate change effect represented by rainfall rareness and high temperature degrees. Moreover, the increasing global climate change along with its effects on the discharge of Euphrates River within the reach extended from Haditha reservoir to Al- Hindiya barrage over the years 2005-2010 were investigated. This study aims to evaluate the climatic changes on the water quality of Euphrates River through its effect on discharge rates for the years from 2005 to 2010 and compared the findings with the results of the studies pre and after the present study. The results showed a remarkable temporally increase in temperature, with noticeable decrease in rainfall rates. Accordingly, discharge was decreased spatially and temporally, it is found a direct correlation between discharge and rainfall. Total dissolved solids as well as major cations (magnesium, calcium, and sodium), along with major anions (chlorides, sulfates and Bicabonates) were showed a negative correlation with discharge. Total dissolved solids and major ions were increased gradually downstream. It was found there is a negative relation between discharge and total dissolved solids and other major ions. Average values of total dissolved solids were 754- 931 ppm in Haditha and Al- Hindiya respectively. Magnesium is the prevailing cation in the Haditha and Al- Hindiya sites. Cations follow the pattern magnesium > sodium > calcium. whereas the sulphates is the prevalent anion, anions follow the pattern sulphates > chloride > bicarbonate. Average concentrations of total dissolved solids as well as major ions of the current study are relatively higher than the studies done before year 2003, and they are close or less than those studies after the year 2003, therefore; it is expected for the Euphrates water quality to be worsening in the future years.

Keywords

Climate change; Discharge rates; Euphrates River; Iraq; Total Dissolved Solids.

To cite this article: Ali, I and Dabbas, M.A (2021) Evaluating the Climatic Change Effect on the water Quality of Euphrates River from Haditha to Al-Hindiya/ Iraq. *Review of International Geographical Education (RIGEO), 11*(5), 4470-4481. doi: 10.48047/rigeo.11.05.325

Submitted: 15-10-2020 ● **Revised:** 19-12-2020 ● **Accepted:** 23-02-2021

Introduction

Iraq, like any arid regions, suffering from high rates of temperatures, scientists have high confidence that global temperatures will increase and continue to rise for years and decades to come. This is largely because of greenhouse gases which are produced by human activities; there are predictions that a temperature rise of 2.5 to 10 degrees Fahrenheit, over the next century, will be accompanied with the precipitation decrease, the probable wide-ranging consequences of climate change which affected the quality as well as quantity of water. This includes the impacts on the rates and of river discharge, changes in the water supply's availability, and different rates of the dissolved solids (IPCC et al., 2013). Rising temperature, moreover, would ultimately bring about increased evaporation. This, in turn, would cause increased salinity and effect negatively on water quality (Al-Ansari et al., 2018). Water quality also associated with a series of geological and climatic factors to form its own ecosystem governed by the laws of its environmental components (Yang et al., 2017). A rising worried is that a heating climate and the rainfall scarcity might result in hydrological problems and decrease in the river flow (Huntington, 2006; Milliman et al., 2008; Shi et al., 2011). Accordingly, Euphrates River reflects a continuous decline in the quality of its water (Al-Ansari, 2016; Al-Najim, 2005). It has been observed in current years that the quality of Euphrates River's water began to deteriorate at intensifying rates, water quality deterioration of Euphrates River is due to the geological formations, land management and agricultural retained irrigation and drainage performs, in addition to the climatic change effect (Al-Ansari, 1998; Al-Ansari, 2016; Al-Ansari, Salameh, & Al-Omari, 1999; Hamad, 2015). Discharge rates is highly affecting on water salinity (Cauquoin et al., 2015). Dam construction by Turkey and Syria decreased the flow regime (Al-Ansari, 2013; Biswas & Olcay, 1997; GAP, 2006). TDS of Euphrates River water in Turkey does not exceed 300 ppm, while it ultimately increases to 600 ppm, especially at the Iraqi – Syrian border reaches to 2100 ppm at Nasiriya city (Odemis, Sangun, & Evrendilek, 2010; Sikandar & Christen, 2012; UN-ESCWA, 2013; WHO, 2011). Discharge rates is directly related with Rainfall availability, which in turn will have a great effect on the quality of the water and the amount of dissolved salts in it, hence high temperature led to increasing evaporation rates and consequently increase TDS in water (Durack, 2015; Rahi & Halihan, 2010). Many studies, in this respect, have inspected the historical changes concerning river discharges at regional or global scales (Jha et al., 2004; Mahageg, 2019; Nakaegawa, Kitoh, & Hosaka, 2013; Shi et al., 2011; Zhang & Schilling, 2006).The main aim of this paper is to explain the negative effects of climate change represented by temperature increase and rainfall decrease on discharge rates and consequently on the water quality over the years (2005- 2010) of Euphrates River extended from Haditha reservoir (upstream of the River) to Al- Hindiya barrage (in the River stretch's middle), the coordinates of the study area are 42°07'35"N– 44°11'37"N latitude to 36°11'34"E– 32°31'59"E longitude (Figure 1).

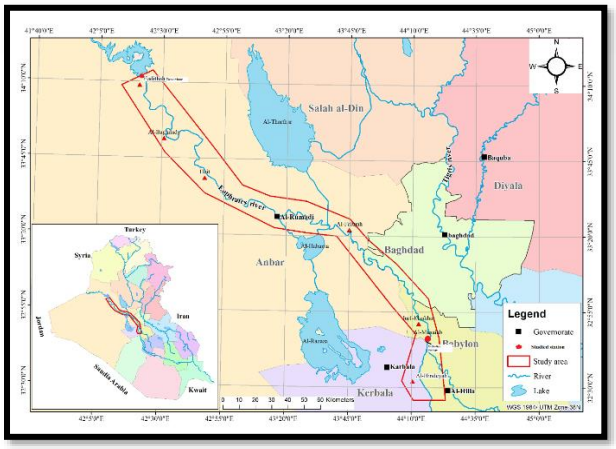

Fig.1: Euphrates River course within the study area

Material and Methods

General review of the literatures, previous studies and collecting geological information of the studied area were done. Preparing the location map of the studied area by using the Geographic Information System (GIS).

Climatological data

Rainfall and temperature were taken from two sources; the first is from Nasa website for period (1981-2019), and the second is from Iraqi Meteorological Organization for Haditha and Al-Hindiya for years (1970- 2010).

Chemical parameters- discharge relation

Monthly records of discharge and the Physio- chemical parameters; total dissolved solids (TDS), major cations (Na^+, Ca^{2+}, as well as Mg^{2+}) along with anions (Cl^-, $SO_4^=$, HCO_3^-) for the period (2005-2010) have taken from the National Centre for Water Resources Management.

Water quality comparison

Water type of the present study were compared with the other studies (pre and after the present study) to show the temporally variation in water type.

Results

Climate parameters/ nasa data

Temperature and Rainfall rates are too vital climatic factors to evaluate the climate due to its influence on water chemistry (Eugster, 1986). Mean annual temperature (°C) for Haditha and Al-Hindiya sites for the years (1981–2019) for data provided by Nasa satellite site were plotted, remarkable increase in temperature values demonstrating from the general trend line (Figure 2 A and B).

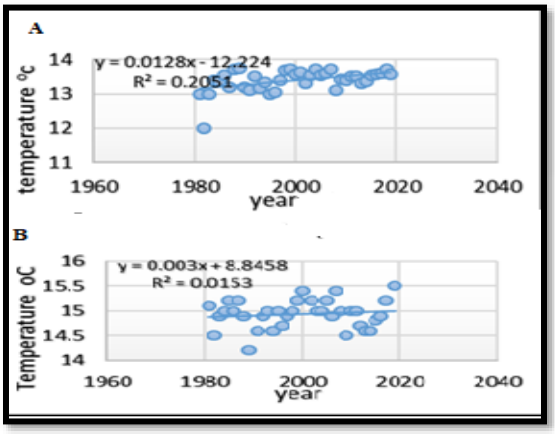

Fig.2. Temperature 1981- 2019, Nasa data
A: Haditha, B: Al- Hindiya

Also, the mean annual rainfall (mm) were plotted against time for the years (1981– 2019) to show a negative correlation indicating the decrease of rainfall with years (Figure 3 A and B). There is an indirect correlation between rainfall and years with remarkable decrease in the values of rainfall,

demonstrating from the line of the general trend.

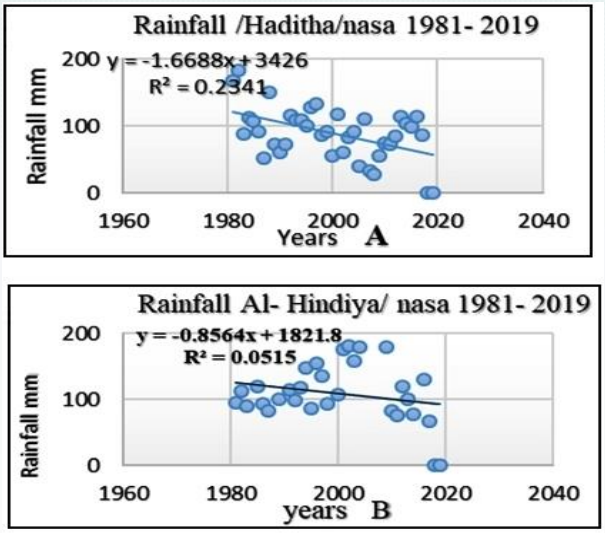

Fig. 3. Rainfall 1981- 2019/ NASA website, A: Haditha B: Al-Hindiya

Rainfall/ Meteorological Organization

To ensure the results, the available climate date obtained from the General Meteorological Organization were plotted for the years (1970- 2010). The results ensure the negative correlation with remarkable decrease in Rainfall rates (Figure 4 A and B).

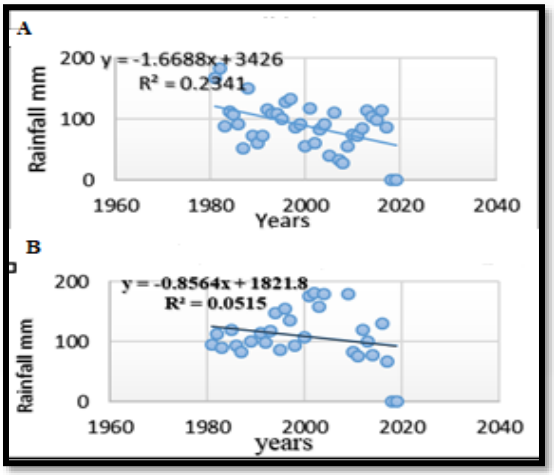

Fig. 4. Rainfall 1970- 2010, Meteorological data A: Haditha B: Al- Hindiya

Discharge- Rainfall Correlations

The discharge usually increases most distinct in the wet winter season, while there are considerable decreases in summer (Wang et. al., 2006). Discharge of the Euphrates River decreased by about 40% after dams' construction by Turkey and Syria on the river (Al-Ansari et al., 2019).
A proportional correlation resulted from rainfall- discharge correlation for the years (1986- 2010) (Figure 5 A and B).

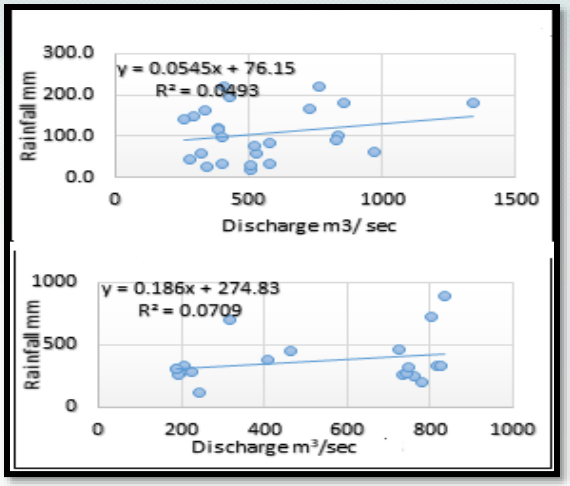

Fig. 5. Discharge- Rainfall (1986- 2010)
A: Haditha, B: Al- Hindiya

Hydrochemistry- Discharge Relation

The examination of quality parameters of water as well as the trend of their variation is beneficial for preparing a quantitative study, such as whether the quality of water is improving or ultimately getting worse over the years. The analyses of these results are essential in planning of water pollution control programs

Discharge- TDS Correlation

TDS has gradually increased especially over the last thirty years (Partow, 2001). Discharge in Haditha reservoir ranged between (250- 710) m^3/ sec with average value 500 m^3/ sec. While it ranged between (85- 465) m^3/ sec in Al- Hindiya barrage. TDS was increased downstream the river, in Haditha TDS ranged between (492- 1104) ppm, with average value 754 ppm, while in Al-Hindiya Barrage ranged between (538- 1200) ppm, with average value 931 ppm. Discharge has inversely correlation with TDS for the years (Figure 6 A and B).

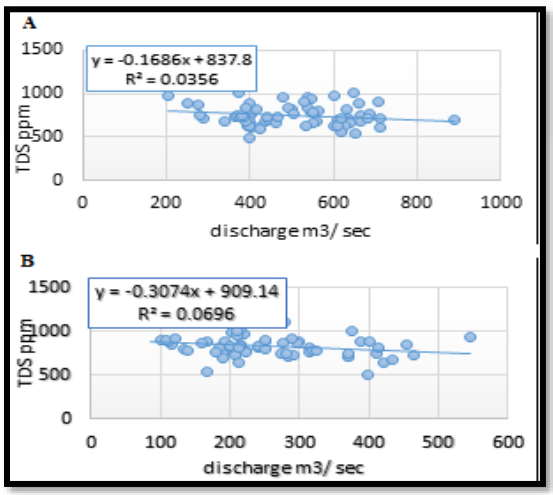

Fig. 6. Discharge- TDS relation 2005- 2010/ A: Haditha, B: Al- Hindiya

Discharge- Ca^{2+} Correlation

Carbonate limestone is the main source of Ca^{2+} dissolved in water (Hem & Survey, 1970). Ca^{2+} in Haditha ranged between (12- 144) ppm with mean value 78.4 ppm, while it increased in Al-Hindiya to range between (45-147) ppm, with average value 96 ppm. There is an inverse correlation between discharge and Ca^{2+} for the years (2005- 2010) (Figure 7 A and B).

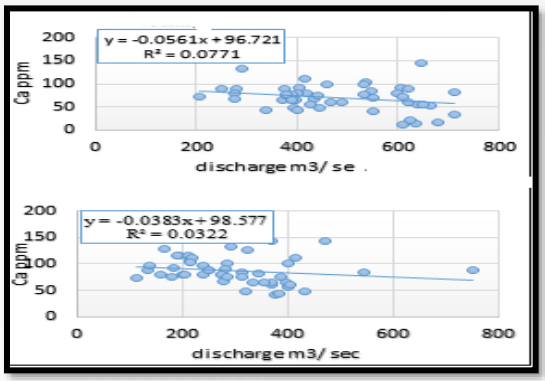

Fig. 7. Discharge- $Ca2^{+}$ relation 2005- 2010 A: Haditha, B: Al- Hindiya

Discharge- Mg^{2+} Correlation

Limestone and dolomite are a main source of Mg^{2+}, High magnesium may be a result of soil erosion (Hassan, 1997). Mg^{2+} and Ca^{2+} was caused water hardness. In Haditha, Mg^{2+} ranged between (34-88) ppm, average value 55.6 ppm, while in Al-Hindiya ranged between (21-194) ppm, average value 107 ppm for the years 2005- 2010. Negative correlation between discharge and Mg^{2+} (Figure 8 A, B).

Discharge- Na^{+} Correlation

Negative correlation resulting from plotting Na^{+} ppm with discharge m^3/ sec in Haditha, and Al-Hindiya sites for the years 2005- 2010. Na^{+} ranged between (43- 160) ppm in Haditha with average value 76 ppm, while it ranged between (74-230) ppm with average value 91 ppm (Figure 9 A and B)

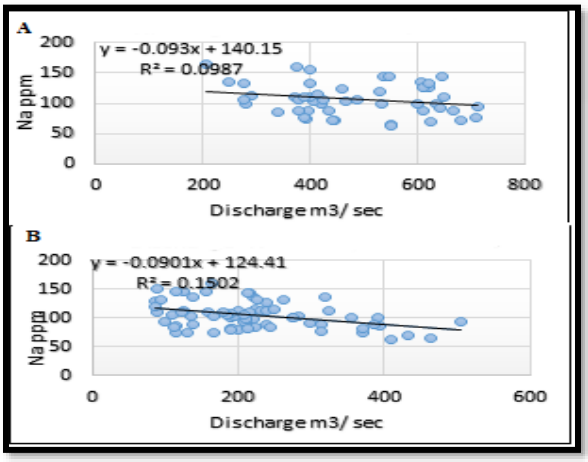

Fig. 9. Discharge- Na^{+} 2005- 2010, A: Haditha B: Al- Hindiya

Anions – Discharge Correlation

Discharge- SO_4^{2-}

Gypsum and Anhydrite as well as pollutants dumped in to the river are the main source of sulfates dissolved in water (Dewis, Levinson, & Bayliss, 1972). An inverse relation resulted from plotting SO_4^{-2} ppm and discharge m^3/ sec in Haditha, and Al- Hindiya sites for the period 2005- 2010. SO_4^{2-} ranged between (221- 461), average value is 341 ppm in Haditha, while it ranged between (225-640) ppm with average value 432 ppm in Al- Hindiya (Figure 10 A and B).

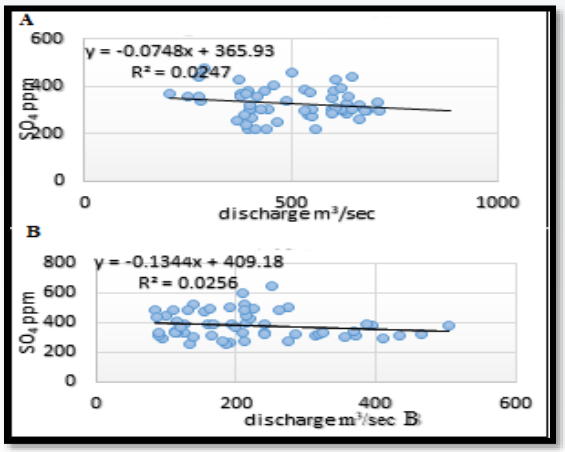

Fig. 10. Discharge- SO_4, 2005- 2010, A: Haditha, B: Al-Hindiya

Discharge - Cl^- Correlation

Negative relation of Cl^- with discharge. In Haditha station, Cl^- ranged between (24-190) ppm with mean value 107 ppm. While Cl^- in Al- Hindiya ranged between (50-208) ppm with mean value 120.6 ppm (Figure11 A, B).

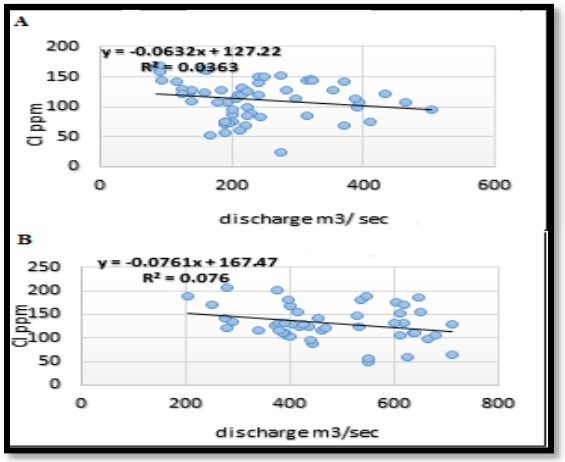

Fig. 11. Discharge- Cl^-, 2005- 2010, A: Haditha, B: Al- Hindiya

Discharge- $HCO3^-$ Correlation

Negative relation between discharge and HCO_3^-, In Haditha; HCO_3^- ranged between (104-189) ppm, average value 142 ppm, while it ranged between (79- 230) ppm, average value is 136 ppm

in Al- Hindiya site (Figures 12 A and B).

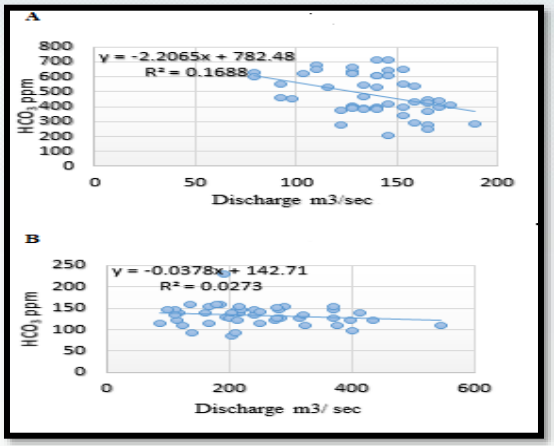

Fig.12. Discharge- HCO_3, A: Haditha, B: Al- Hindiya

Discussion

The literatures reflected that the quality of Euphrates River's water is highly and seriously affected by climate change. Moreover, the salinity that rises along the Euphrates River reaches southward. The deterioration of water quality. TDS analysis showed an inverse correlation with discharge from Haditha to Al- Hindiya site for the years (2005- 2010); TDS in Haditha ranged between (492- 1104) ppm, with average value 754 ppm. While in Al- Hindiya barrage are ranged between (538- 1200) ppm, with average value 931 ppm. The salinity is increased temporally with time, therefore the average TDS and the Hydro chemical parameters of this research for the period (2005-2010) were compared with other studies Table (1). Some of these previously studied were before 2003 such as (Al-Obaidi, 1983; Banat & Al-Rawi, 1986; Salman, 1986), where others were after year 2003 such as (Awadh & Ahmed, 2013; Bomola, 2012; Hamad, 2015; Ryadh, 2004). At Haditha station, previous studies showed that all Hydro chemical concentrations are less than or close to the current study values (Al-Obaidi, 1983; Banat & Al-Rawi, 1986; Salman, 1986). Average TDS in the present study was relatively higher than the previous studies; it was (494- 779) ppm in (Al-Obaidi, 1983), (504- 980) ppm in (Banat & Al-Rawi, 1986); average TDS was (456- 805) ppm in (Salman, 1986); and (400-590) ppm in (Ryadh, 2004) in Haditha and Al- Hindiya respectively (Table 1). Actually the water quality of Euphrates River before 2003 reveals that the water quality rich in bicarbonates ions which indicates the clear effect of rainfall in the past decades that decreased the concentration of the salinity by dilution process on the Euphrates River.

When comparing the results of the research with the studies after year 2003, show that there is an increase in TDS and that water quality was changed to Ca-SO4 and Mg-SO_4 which indicates the high solubility of evaporated rocks and the effect of water storage in Haditha reservoir, meaning that the results of previous studies agree with the current research idea that water quality changes during the time and this is due to the impact of climate changes and the deficiency of discharge of the Euphrates River (Awadh & Ahmed, 2013; Bomola, 2012; Hamad, 2015; Ryadh, 2004). Average TDS in the present study was relatively higher than the previous studies; it was (494- 779) ppm in (Al-Obaidi, 1983), (504- 980) ppm in (Banat & Al-Rawi, 1986); average TDS was (456- 805) ppm in (Salman, 1986); and (400-590) ppm in (Ryadh, 2004) in Haditha and Al- Hindiya respectively (Table 4.1). While average TDS value in the researches after year 2003 were (766-882) ppm in Haditha al- Hindiya respectively as analyzed by (Bomola, 2012; Hamad, 2015) results indicated 1000 ppm in al- Hindiya and (Awadh & Ahmed, 2013) results reflect 1082 ppm at Al- Hindiya barrage as well (Table 1).

As for Al- Hindiya station, previous studies before 2003 showed that all Hydrochemical concentrations are less than or close to the current study values, while when comparing the results

of this research with the studies after year 2003, show that there is an increase in TDS, but they were limited in their effect on the Euphrates River's quality in Haditha and Al- Hindiya stations (Al-Obaidi, 1983; Banat & Al-Rawi, 1986; Salman, 1986). Such results of previous studies are in concordance with the current research idea that water quality changes during the time and this is due to the impact of climate changes and the deficiency of discharge of the Euphrates River (Awadh & Ahmed, 2013; Bomola, 2012; Hamad, 2015; Ryadh, 2004).

Generally speaking, the quality of Euphrates River's water at Al- Hindiya station, the concentrations of sulfates, calcium, and magnesium are relatively higher than Haditha Barrage water quality due to the chemical dissolution processes but it is logical and acceptable due to the flow of the Euphrates River from south Haditha that the river pass near Hit and Kubaisa sulfuric springs, but with limited effect on the quality of the water (Awadh & Ahmed, 2013). Moreover, the same conclusion was reached for average of the cations' concentrations $Ca2^{+}$, Mg^{2+}, Na^{+}, and anionsSO_4^{2-}, Cl^{-} as well as HCO_3^{-}, that the average concentrations of the cations and the anions of the current study are relatively higher than the studies done before year 2003, and they are close or less than those studies after the year 2003 (Table 1).Such finding considered an evidence of water deterioration as the influence of discharge decrease which in turn is affected by the climate changes represented by the scarcity of rainfall and rising the temperatures and consequently the evaporation from Haditha to Al- Hindiya site throughout the years (Table 1).

Conclusion

1- Climatic change affecting on rainfall rareness and temperature increase over the years (Figures 3.1; 3.2; 3.3; and 3.4) in
Haditha and Al- Hindiya meteorological stations respectively.
2- There is a direct relationship between discharge and rainfall rates (Figure 3.5 A, B).
3- Total dissolved solids and major ions were increased spatially and temporally, so the water quality of Euphrates River was deteriorated.
4- Physio- chemical analysis of the present study from Haditha to Al- Hindiya for the years (2005-2010) were shown inverse correlation with discharge rates, this mean when the discharge decreased by influenced of climate change.
5- The results of physio- chemical analysis of the present study were compared with the studies before year 2003. The previous studies reflecting salinities relatively lower than the current study, while the studies after year 2003 were roughly converging in its values with close or relatively higher than the current study.

Acknowledgements

The researchers would like to express thanks to the National Centre for Water Resources Management/the Ministry of Water Resources for offering the necessary information and analysis to complete this research as we thank Professor Moutaz Al Dabbas for his good supervision and continuous follow-up of the research to be at the appropriate level. Authors are very grateful to the reviewers, the Editor of Kuwait Journal of Sciencesfor the valuable comments that improved the article.

Table 1:
Compression between physio- chemical parameter of the Euphrates River of this research with other studies

Parameter (ppm)	Present study 2005-2010		Al-Obaidi (1983)		Banat and Al-Rawi (1986)		Salman (1986)		Ryadh (2004)		Bomola (2012)		Awadh and Ahmed (2013)	Hamad (2015)
	Haditha.	Hindiya.	Haditha.	Hindiya	Haditha	Hindiya	Haditha.	Hindiya.	Haditha	Hindiya	Haditha	Hindiya	Hadith. Hindiya.	Hadith. Hindiya.
TDS	754	931	494	779	504	980	406	805	590	687	766	882	1082	1000
Ca^{+2}	78.4	96	37.4	68.5	44	113	72	93	80	165	80	123	135	110
Mg^{+2}	55.6	107	28.6	29.7	25	29	46.5	60	38	78	42.7	90	117.5	67
Na^{+}	76	82	89	71.2	44	78	67	88	70	120	82	131	141.5	100
SO_4^{-2}	341	432	91.8	181	211	231	112	169	220	400	270	378	444	300
Cl^{-}	107	120.6	70.5	130	20	131	76	114	120	125	112	149	169.5	180
HCO_3	142	136	123	125	145	114	177	152	340	370	-	-	-	-
Water Type	$MgSO_4$	$MgSO_4$	$MgHCO_3$	$CaSO_4$	$CaSO_4$	$CaSO_4$	$MgHCO_3$	$MgSO_4$	$CaSO_4$	$CaSO_4$	$MgSO_4$	$CaSO_4$	$MgSO_4$	$MgSO_4$

References

Al-Ansari, N. (1998). Water resources in the Arab countries: Problems and possible solutions. Paper presented at the UNESCO International Conference on World Water Resources at the Beginning of the 21st Century.

Al-Ansari, N. (2013). Management of water resources in Iraq : perspectives and prognoses. Engineering, 5(6), 667-684. doi: 10.4236/eng.2013.58080

Al-Ansari, N. (2016). Hydro-Politics of the Tigris and Euphrates Basins. Engineering, 8(3), 140-172. doi: 10.4236/eng.2016.83015

Al-Ansari, N., AlJawad, S., Adamo, N., Sissakian, V. K., Laue, J., & Knutsson, S. (2018). Water Quality within the Tigris and Euphrates Catchments. Journal of Earth Sciences and Geotechnical Engineering, 8(3), 95-121.

Al-Ansari, N., Jawad, S., Adamo, N., & Sissakian, V. (2019). Water Quality and its Environmental Implications within Tigris and Euphrates Rivers. Journal of Earth Sciences and Geotechnical Engineering, 9(4), 57-108.

Al-Ansari, N., Salameh, E., & Al-Omari, I. (1999). Analysis of rainfall in the badia region. Jordan, Al al-Bayt University Research paper, 1, 66.

Al-Najim, M. (2005). Impact of Tigris and Euphrates Water Crisis on The Environmental Catastrophe of Iraqi Marsh Lands. The Iraqi Geological Journal, 34(38), 91-100.

Al-Obaidi, A. S. M. (1983). Hydrogeochemistry of the Euphrates River and the probable Enviromental Pollution from Qaim to Hilla (Unpublished, in Arabic).

Awadh, S. M., & Ahmed, R. M. (2013). Hydrochemistry and pollution probability of selected sites along the Euphrates River, Western Iraq. Arabian Journal of Geosciences, 6(7), 2501-2518. doi: 10.1007/s12517-012-0538-1

Banat, K., & Al-Rawi, Y. (1986). Hydrogeochemistry, clay minerals and carbonates of the Euphrates River Iraqi. Iraqi J Sci, 27(3), 347-362.

Biswas, K. A., & Olcay, Ü. I. (1997). Water Resources Development in a Holistic Socioeconomic Context-The Turkish Experience. Int. Journal Of Water Resources Development, 13(4), 437-581.

Bomola, A. A. (2012). Temporal and spatial changes in water quality of the Euphrates river - Iraq. (MSc thesis.).

Cauquoin, A., Jean-Baptiste, P., Risi, C., Fourré, É., Stenni, B., & Landais, A. (2015). The global distribution of natural tritium in precipitation simulated with an Atmospheric General Circulation Model and comparison with observations. Earth and Planetary Science Letters, 427, 160-170. doi: https://doi.org/10.1016/j.epsl.2015.06.043

Dewis, F. J., Levinson, A. A., & Bayliss, P. (1972). Hydrogeochemistry of the surface waters of the Mackenzie River drainage basin, Canada—IV. Boron-salinity-clay mineralogy relationships in modern deltas. Geochimica et Cosmochimica Acta, 36(12), 1359-1375. doi: https://doi.org/10.1016/0016-7037(72)90067-1

Durack, P. J. (2015). Ocean Salinity and the Global Water Cycle. Oceanography, 28(1), 20-31. doi: https://www.jstor.org/stable/24861839

Eugster, H. P. (1986). Minerals in hot water. American Mineralogist, 71(5-6), 655-673.

GAP. (2006). South-eastern Anatolia Project: latest situation. .

Hamad, S. O. (2015). Compared Some Water Characteristics of Tigris River With Euphrates River. Journal of university of Anbar for Pure science, 9(3).

Hassan, F. M. (1997). College of Education for Woman - University of Baghdad. Iraq Journal,, 8(1), 22.

Hem, J. D., & Survey, G. (1970). Study and Interpretation of the Chemical Characteristics of Natural Water: U.S. Government Printing Office. Retrieved from https://books.google.com.pk/books?id=kJRGAQAAMAAJ.

Huntington, T. G. (2006). Evidence for intensification of the global water cycle: Review and synthesis. Journal of Hydrology, 319(1), 83-95. doi: https://doi.org/10.1016/j.jhydrol.2005.07.003

IPCC, Alexander, L., Allen, S., Bindoff, N., Breon, F.-M., Church, J., . . . Xie, S.-P. (2013). Climate change 2013: The physical science basis, in contribution of Working Group I (WGI) to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC).

Jha, M., Pan, Z., Takle, E. S., & Gu, R. (2004). Impacts of climate change on streamflow in the Upper Mississippi River Basin: A regional climate model perspective. Journal of Geophysical Research: Atmospheres, 109(D9). doi: https://doi.org/10.1029/2003JD003686

Mahageg. (2019). Hydrology and Sediment Transport Studied of Al- Garraf RiverIraq.(Unpublished). (Ph.D), university of Baghdad, .

Milliman, J. D., Farnsworth, K. L., Jones, P. D., Xu, K. H., & Smith, L. C. (2008). Climatic and anthropogenic factors affecting river discharge to the global ocean, 1951–2000. Global and Planetary Change, 62(3), 187-194. doi: https://doi.org/10.1016/j.gloplacha.2008.03.001

Nakaegawa, T., Kitoh, A., & Hosaka, M. (2013). Discharge of major global rivers in the late 21st century climate projected with the high horizontal resolution MRI-AGCMs. Hydrological Processes, 27(23), 3301-3318. doi: https://doi.org/10.1002/hyp.9831

Odemis, B., Sangun, M. K., & Evrendilek, F. (2010). Quantifying long-term changes in water quality and quantity of Euphrates and Tigris rivers, Turkey. Environmental Monitoring and Assessment, 170(1), 475-490. doi: 10.1007/s10661-009-1248-3

Partow, H. (2001). The Mesopotamian marshlands :demise of an ecosystem early warning and assessment technical report, UNEP/DEWA/TR.01–3 Rev. 1 In V. p.-. 865. (Ed.), (Vol. 36). Nairobi :: Division of Early Warning and Assesment, UNEP.

Rahi, K. A., & Halihan, T. (2010). Changes in the salinity of the Euphrates River system in Iraq. Regional Environmental Change, 10(1), 27-35. doi: 10.1007/s10113-009-0083-y

Ryadh. (2004). Evaluation of Environmental Monitoring program for Natural Rivers: Case Study of Euphrates River. (Unpublished). (Ph.D., Environmental Geochemistry), university of Baghdad.

Salman, H. (1986). Geochemistry and Hydrology of Euphrates River- Iraq. (MSc thesis, (Unpublished, in Arabic).).

Shi, X., Mao, J., Thornton, P. E., Hoffman, F. M., & Post, W. M. (2011). The impact of climate, CO2, nitrogen deposition and land use change on simulated contemporary global river flow. Geophysical Research Letters, 38(8). doi: https://doi.org/10.1029/2011GL046773

Sikandar, P., & Christen, E. W. (2012). Geoelectrical Sounding for the Estimation of Hydraulic Conductivity of Alluvial Aquifers. Water Resources Management, 26(5), 1201-1215. doi: 10.1007/s11269-011-9954-3

UN-ESCWA, B. (2013). Inventory of Shared Water Resources in Western Asia Jordan River Basin. Beirut: United Nations Economic and Social Commission for Western Asia. Federal Institute for Geosciences and Natural Resources.

WHO, G. (2011). Guidelines for drinking-water quality. World Health Organization, 216, 303-304.

Yang, M., Yao, T., Wang, H., & Gou, X. (2017). Correlation between precipitation and temperature variations in the past 300 years recorded in Guliya ice core, China. Annals of Glaciology, 43, 137-141. doi: 10.3189/172756406781812384

Zhang, Y. K., & Schilling, K. E. (2006). Increasing streamflow and baseflow in Mississippi River since the 1940s: Effect of land use change. Journal of Hydrology, 324(1), 412-422. doi: https://doi.org/10.1016/j.jhydrol.2005.09.033