Kufa Journal of Engineering
Vol. 16, No. 4, October 2025, P.P. 235-251
Article history: Received 11 October 2024, last revised 31 December 2024,
accepted 25 January 2025

STUDYING THE IMPACT OF DEAD STORAGE USE ON THE EUPHRATES RIVER WATER QUALITY (RAMADI BARRAGE TO FALLUJA BARRAGE AS A CASE STUDY)

Wisam Abdulabbas Abidalla[1] and Basim Sh. Abed[2]

[1] Department of Water Resources Engineering, College of Engineering, University of Baghdad, Baghdad, Iraq. Email: wessam.abd2310@coeng. uobaghdad.edu.iq

[2] Department of Water Resources Engineering, College of Engineering, University of Baghdad, Baghdad, Iraq. Email: bassim.shabaa@coeng.uobaghdad.edu.iq

https://doi.org/10.30572/2018/KJE/160414

ABSTRACT

The Stream Quality Model (QUAL2KW) used for simulation the Quality of Euphrates River Water. The study area extends along (78 km) of the river path from downstream of Ramadi Barrage to upstream of Falluja Barrage. Tharthar-Euphrates Canal carries the dead storage water from Tharthar reservoir to the Euphrates River at the meet point (52 km) from downstream of Ramadi Barrage. Statistical tests conducted between values of water quality parameter concentrations obtained from sites with the values simulated by this model. The results of statistical tests showed great convergence and gave reliability and credibility in adopting the use of this model for river quality simulation. To evaluate the effect of using the reservoir dead storage water on the river water quality, model operated with scenarios represented different releases of dead storage water by (30%, 60%, and 100%) lead to increases in these quality parameters concentration by (3%-9%), (5%-14%) and (8%-19%) respectively, which does not significantly affect the Euphrates River's water quality. The results of applying the various scenarios showed that 30% is optimal for maintaining the quality of river's water for drinking purposes after performing the required treatments, and 100% for maintaining the quality of river's water for irrigation purposes without affecting the various plants.

KEYWORDS

Euphrates River, Dead storage, Qual2kw model, Water quality, Water pollution.

1. INTRODUCTION

Euphrates River one of two main rivers in Iraq, enter Iraqi border at the Husaiyba region in Al-Qai'm District of Al-Anbar City. The river basin covers 450,000 km^2 with (47%) percent of this area in Iraq (Al-Hassanyi, 2023). In recent years, this river has witnessed a significant reduction in water supplies originating from the Syrian territories, resulting in a loss exceeding 60% of water reaching the Syrian-Iraqi border (Abbas, 2018; Al-Ansari, 2014). This decline has led to challenges in meeting the water demands of central and southern Iraq. To mitigate the effects of drought and water scarcity, the Ministry of Water Resources resorted to pumping approximately (90-100) cubic meters per second from reservoirs of Tharthar Lake in the last two years. The utilization of water dead storage from this reservoirs which typically the lower portion of a reservoir inaccessible under normal conditions, may accumulate sediments, nutrients, and other substances over time, though crucial for water management, raises concerns regarding its potential impact on water quality (Abed et al., 2021). Understanding the implications of dead storage utilization on water quality is imperative for effective reservoir management and the preservation of downstream ecosystems. As is known, the concept of water pollution means changing in chemical and physical that occurrence in quality of water, indirectly or directly, that affects living organisms negatively or makes water unsuitable in various uses (Ferreira et al., 2020; Azeez, 2024). Pollution divided into two main kinds, the first kind represent anatural pollution such as changing in water temperature and increasing in water salinity, or increasing in suspnded particles, the other kind of pollution is a chemical which included many types such as sewage water pollutions and pollution due to agricultural waste like agricultural fertilizers and pesticides (Ojo et at., 2021; Al-Juhaishi et at., 2024). This research endeavours to impacts of uses the dead storage water of Tharthar reservoir on the Euphrates River water quality.

2. METHODOLOGY

2.1. The Study Area

Study area spans from downstream of Ramadi Barrage (33.4366º N, 43.2563 º E) at (0.00 km) to the upstream of Falluja Barrage (33.2833º N, 43.7725º E) at (78.00 km) in river reach shown in Fig.1, includes the Tharthar-Euphrates Canal (located at 33.3990 N, 43.6020 E) about 50 km from downstream of Ramadi Barrage, which carring dead storage water from the Tharthar Reservoir to the Euphrates River in large quantities to enhance the shortage in this river and cover water requirment within the regions of central and southern Iraq.

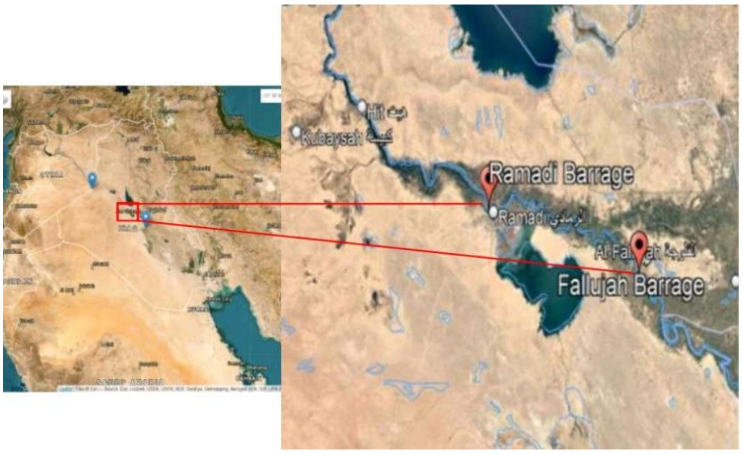

Fig. 1. The study area location within Euphrates River (After Google Satellite, 2024)

2.2. The Quality Model

2.2.1. QUAL2KW Model Description:

QUAL2KW is stream and river water quality model; it is a modernized version of the QUAL2K model. This model can be characterized as follows (Chapra, 2003; Elliott et at., 2002): (1) Flow hydraulics characteristics represent the steady-nonuniform flow, in which model considers that channal is well mixed laterrally with vertically. ; (2) of diurnal time scale, the model simulaties water quality, heat balance variables and temperature.; (3) Simulating of point loads and the diffuse loads by this model in Heat mass and inputs (Mustafa et at., 2017). For this model, the river reach in the study area split into segments with unequal distance.

2.2.2. Quality parameters:

Contamination due to physical, chemical, biological or microorganisms decrease quality of water and causing toxic to the environment and humans (Hobson, 2013). The river discharge is primary factor in running water environmentally and modifying or changing this discharge is acompanied by changing in the other environmental parameters (Kori et al., 2013). The water's biological, chemical and physical properties represent the most important factors that determine the uses of water for various purposes, as well as the growth and spread of aquatic organisms (Al-Hashimi, 2009)**.** (Brusseau et al., 2019) showed that aquatic organisms appear to have a high sensitivity to changes, whether chemical or physical in the aquatic environmentally in which they lives, and these factors affects nature of the organisms life that lives in them (Hashim and Abdulhadi, 2022). In the study area, due to the addition of water from the reservoirs of Tharthar Lake to the waters of the Euphrates River, it is expected that changes will occur in most water quality parameters such as, TSS, EC, pH, Alkalinity, T.N, and T.P, which may affect the nature of the different uses of this water for the areas located in the middle and south of the river reach.

2.3. River Discretization:

The (78 km) of river reach from (0.00 km) d/s of Ramadi Barrage to (78.00 km) u/s of Falluja Barrage divided into seven segments with unequal distances or lengths shown in Fig.2. Discharge, location and distance of point sources listed in Table 1. For expressed relationship between the depth of water with flow discharge, the Manning equation was used (Tuozzolo et al., 2019). This river represent a natural stream in which some of its reaches are straight and clean, and the other are meandering with some weeds. In the study area, Manning's coefficient was taken (0.026) (Hashim, 2023). The values of the river bed levels at the upstream and downstream of each cross section, and the longitudinal slope with path distance of the river between each two sections were calculated, as well as the right and left river side slope.

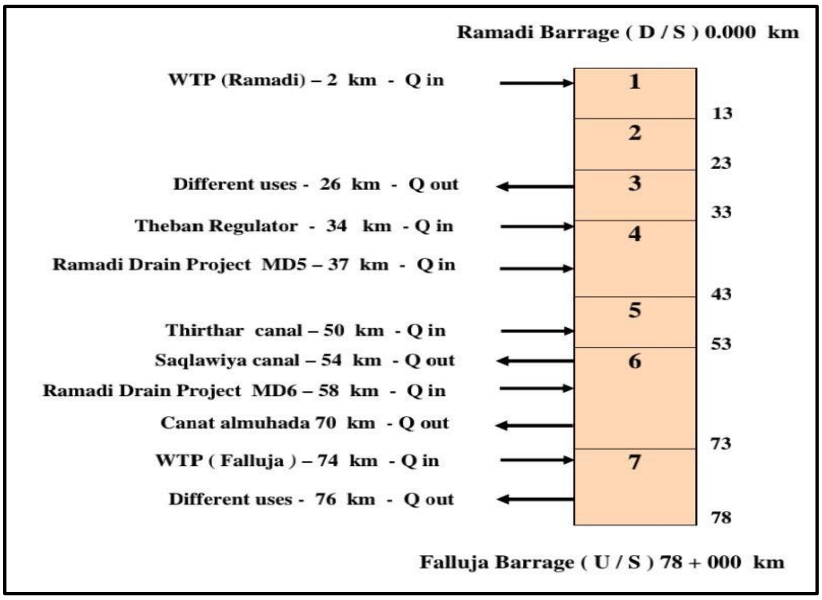

Fig. 2. System segments with sites of pollution source along the Euphrates River

Table 1: Discharge, location, and distance of point sources (inflow - outflow)

Rank	**Name**	**Types of Sources**	**Discharge (m^3/sec)**	**Location**		**Distance From (0) Location-(km)**
				N	**E**	
1	W.T.P. (Ramadi)	Wastewater T.P.	+ 0.30	33.414^{0}	43.266^{0}	2.0
2	Theban regulator	Irrigation channel	Close	---	---	34.0
3	Al-Ramadi drain-project (MD5)	Drainage channel	+ 2	33.406^{0}	43.511^{0}	37.0
4	Thirthar – Euphrates Channel	Irrigation channel	+195	33.399^{0}	43.602^{0}	50.0
5	Saqlawiya Canal	Irrigation channel	- 7	33.394^{0}	43.609^{0}	54.0
6	Al-Ramadi Drain Project (MD6)	Drainage channel	+ 3	33.344^{0}	43.660^{0}	58.0
7	Al-Muhada Canal	Irrigation Channel	- 35	33.318^{0}	43.773^{0}	70.0
8	WTP (Falluja)	Wastewater T.P.	+ 0.1	33.309^{0}	43.783^{0}	74.0

2.4. Sampling Sites

Several sites on Euphrates River for water samples were chosen, as listed in Table 2 and shown in Fig.3 in two periods April and July (2024) at (78) km of the river path. The chosen sites involve the d/s of Ramadi Barrage, the meeting point of the Tharthar Canal with the Euphrates River, the wastewater treatment plant, and other sites, ending with the u/s of the Falluja Barrage. Sampling from those sites done according to procedure based on the Ministry of Water Resources (Kassir et al., 2015). Field visits were conducted to various sites in the study area that were previously identified with the help of an engineering team from the National-Centre of Water Resources management. The river discharge at the zero location and other sites along the river reach were measured using the water discharge measuring device (A.D.C.P-M9) (Mueller et al., 2013). In addition, and to prevent unexpected property change, using the procedure of dipping the clean plastic bottles at a depth of (0.30 m) from the river water surface that water sample obtained.

Table 2: Distance with location of samples sites

Point no. on map	Name of Location	Distance from (0.0) location - km	Location - Coordinate N	E
1	Al-Ramadi Barrage d/s	0.00	33.4366^0	43.2563^0
2	Al-khalidiyah	28.0	33.4154^0	43.4667^0
3	Tharthar-Euphrates	52.0	33.3948^0	43.6098^0
4	Al-Falluja Barrage u/s	78.0	33.2833^0	43.7725^0

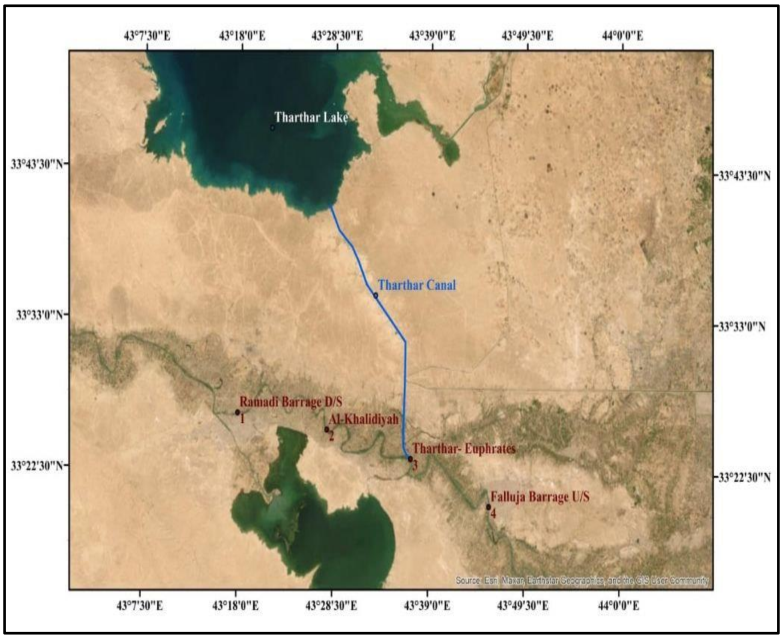

Fig. 3. Scheme of sampling sites with location of the Tharthar Lake (After Google Satellite, 2024)

3. INPUT DATA

QUAL2KW model required several input data that include a geographic characteristic such as (length of segment, location, and the coordinate) as listed in Table 3.

Cross-sections of Euphrates River collected by engineering teams from the "National Centre for Water Resources Management" in the year (2023) and from these cross-sections obtained parameters which required to apply Manning equastion such as, left - right side slope, longitudinal bed slope, river bed width and the elevation for each segment as listed in Table 4.

The Manning roughness-coefficient for the river reach within the study area was calculated in other studies (Hashim and Azzubaidi, 2023; Hadi, Z.A., B.H., and Al-Juhaishi, M.R., 2023) and used in this study.

Table 3: Segments length and downstream locations with coordinates

Segment	Length(km)	Downstream location (km)	Downstream Coordinate	
			Latitude - N	Longitude - E
0	0	0	33.436^0	43.256^0
1	13	13	33.433^0	43.434^0
2	10	23	33.428^0	43.496^0
3	10	33	33.410^0	43.554^0
4	10	43	33.390^0	43.617^0
5	10	53	33.383^0	43.672^0
6	20	73	33.352^0	43.750^0
7	5	78	33.168^0	43.781^0

Table 4. Manning formula parameters with elevation of the Euphrates River within study area.

Segment	Downstream Location (km)	Elevation		Manning formula Parameters				
		U.S (m)	D.S (m)	Ave. Bed Width (m)	Left Side Slope	Right Side Slope	River Bed Slope	Manning-Roughness
0	0+00	---	43.89	185	0.13	0.12	---	0.026
1	13+00	43.89	43.7	123	0.13	0.15	0.00001	0.026
2	23+00	43.7	41.76	140	0.15	0.12	0.00019	0.026
3	33+00	41.76	40.0	130	0.18	0.08	0.00017	0.026
4	43+00	40.0	39.4	125	0.12	0.09	0.00006	0.026
5	53+00	39.4	37.65	155	0.13	0.08	0.00017	0.026
6	73+00	37.65	35.95	150	0.12	0.12	0.00016	0.026
7	78+00	35.95	34.13	205	0.09	0.11	0.00018	0.026

The input data required in QUAL2KW model that enter simulated river segments for upstream, different sites, and downstream river reach within study area which represnt the point sources were listed in Table 5 and Table 6.

Table 5: The observed water quality parameters for (headwater, point-sources, and different locations along reach of the Euphrate River – in April month

Name of Location	Distance from (0) location-(km)	(Q) (m^3/ sec)	EC (μs /cm	TSS (mg/L)	pH	Alkali-nity (mg/L)	T. N. (μg/L)	T. P. (μg/L)
Ramadi Barrage D/S	0.0	188	1103	40	8.2	24	14.67	0.10
WTP (Ramadi)	2.0	0.30	2600	95	8.1	22	165.6	1.10
Al-khalidiyah	28.0	183	1263	40	8	32	14.4	0.10
Al-Ramadi Drain Project / (MD5)	37.0	2.0	6115	50	8.1	155	8.61	0.20
Tharthar – Canal	50.0	195	1303	90	8.2	48	12.74	0.21
Tharthar-Euphrates	52.0	378	1380	60	8.2	48	23.1	0.15
Al-Ramadi Drain Project / (MD6)	58.0	3.0	4170	45	8.3	160	4.62	0.11
WTP (Falluja)	74.0	0.10	2460	88	8.1	24	151.8	1.20
Falluja Barrage U/S	78.0	371	1275	55	8.2	28	14.8	0.10

Table 6: The water quality parameters (observed) for headwater, point sources, and different locations along reach of the Euphrates River - July month

Location	Distance from (0.00 km) - (km)	(Q) (m^3/ sec)	EC (µs /cm	TSS (mg/L)	pH	Alkali-nity (mg/L)	T. N (µg/L)	T. P (µg/L)
Ramadi Barrage D/S	0.0	239	1015	56	7.9	38	7.78	0.10
WTP (Ramadi)	2.0	0.30	2860	90	8.4	30	57.45	1.3
Al-khalidiyah	28.0	233	1010	60	7.8	34	7.88	0.12
Al-Ramadi Drain Project / (MD5)	37.0	2.0	6170	60	8.1	170	10.32	0.10
Tharthar – Canal	50.0	173	1663	57	8.3	46	16.17	0.21
Tharthar-Euphrates	52.0	406	1168	75	8.2	48	8.16	0.23
Al-Ramadi Drain Project / (MD6)	58.0	3.0	4240	50	8.0	176	2.67	0.14
WTP (Falluja)	74.0	0.10	2630	85	8.3	28	49.54	1.4
Falluja Barrage U/S	78.0	397	1160	63	7.8	42	10.49	0.21

4. RESULTS AND ANALYSIS

4.1. Modelling of Qual2kw

The Qual2.kw model used to simulate and predict the concentrations of water quality parameters for Euphrates River.This model was calibrated by applied the statistical tests to the values of water quality parameters obtained and simulated during first round in (April-2024), in addition, the model validated in the second round in (July-2024). In the operation of model, the observed parameters data which collected from sites used as inputs in model software, such as the hydraulic data, hydrological data, climate data, and the others which pertain to this river, and a computation step has been set to 1.8 min. Several parameters of water quality, such as Electrical Conductivity (EC), Total Suspended Solids (TSS), Hydorgen Ion (ph), Alkalinity (CaCO3), Total Nitrogen (T.N.), and Total Phosphorus (T.P.) are included in this study. The Qual2kw operating in the Euphrates River for water depth with distance is shown in Fig.4. The Qual2kw modelling for observed and simulated flow discharge with distance is shown in Fig.5. and for water quality parameters is shown in Figs. 6-11 on April 13–14, 2024, for the first round.

The Qual2kw operating in Euphrates River for water depth with distance is shown in (Fig.12) The Qual2kw Modelling for flow discharge for both observed and simulated data is shown in (Fig.13) and for water quality parameters shown in Figs.(14-19). on July 20–21, 2024, in the second round.

From the above curves in observed - simulated quality parameters values, the observed values curves that starting from (0.00 km) station at downstream of Ramadi Barrage still similar and not show big differences to the last station (78.0 km) at upstream of Falluja Barrage, and have same trend as the simulated curves that provided by the quality model.

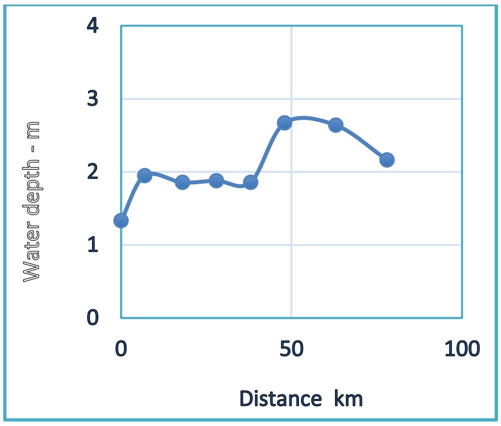

Fig. 4. Water depth VS. Distance

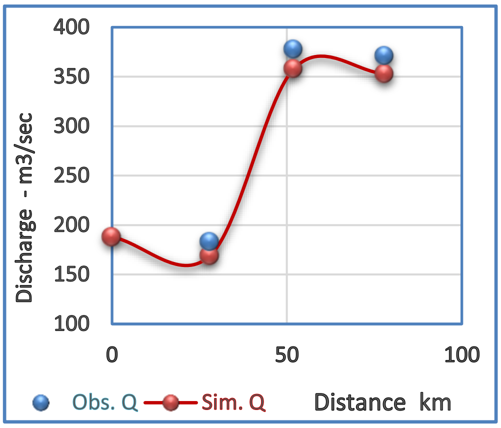

Fig. 5. Observed – Simulated (Q) VS. Distance

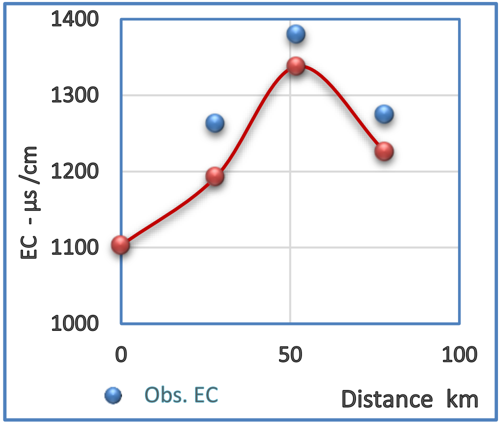

Fig. 6. Observed - Simulated (EC) VS. Distance

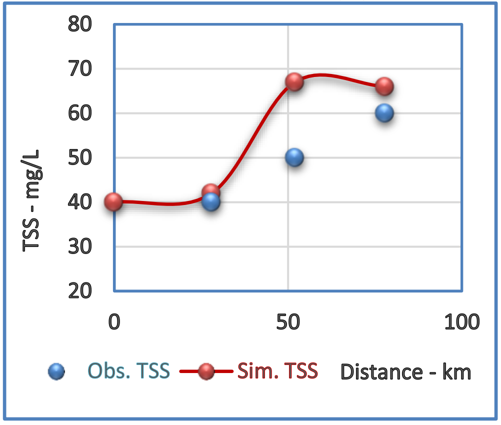

Fig. 7. Obs. – Sim. (TSS) VS. Distance

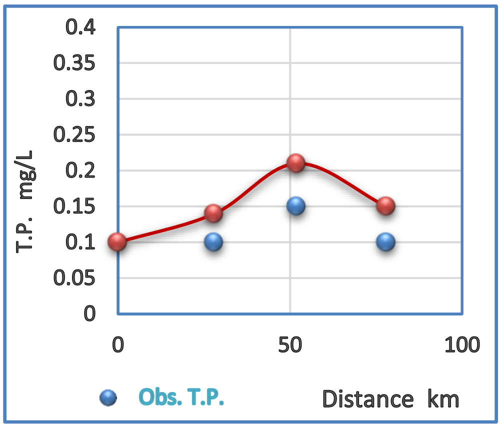

Fig. 8. Obs. – Sim. (T.P.) VS. Distance

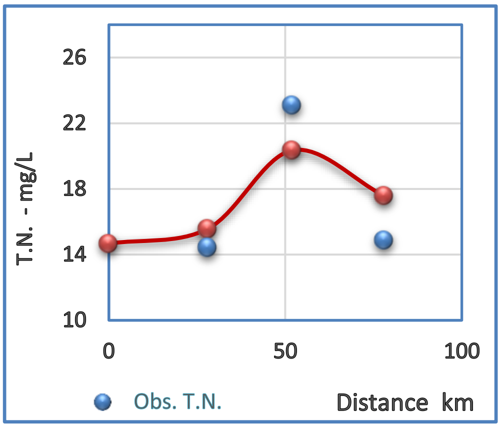

Fig. 9. Obs. – Sim. (T.N.) VS. Distance

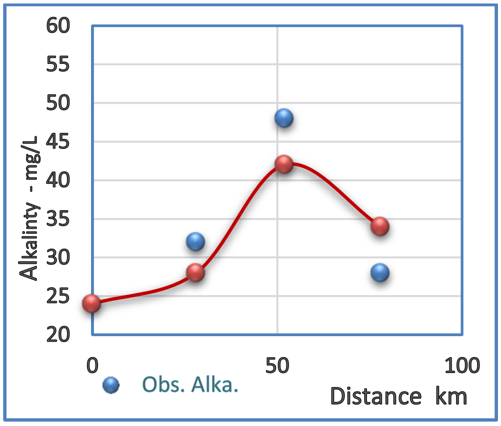

Fig. 10. Obs. - Sim. (Alkalinity) VS. Distance

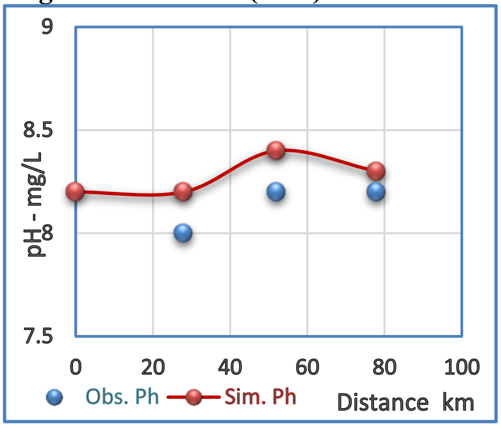

Fig. 11. Obs. – Sim. (pH) VS. Distance

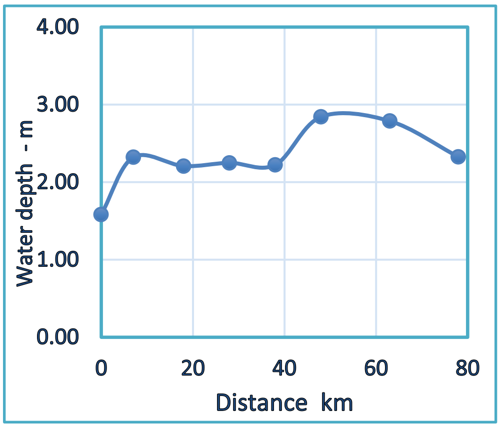

Fig. 12. Water depth VS. Distance

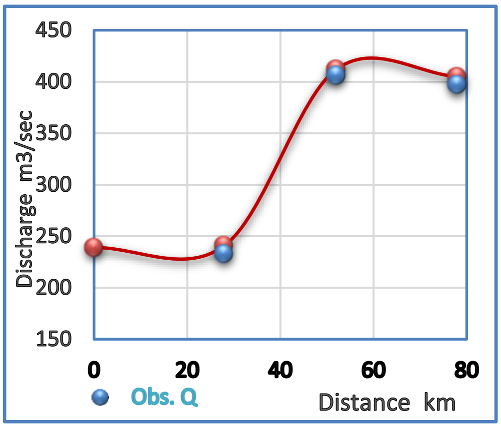

Fig. 13. Obs. – Sim. (Q) VS. Distance

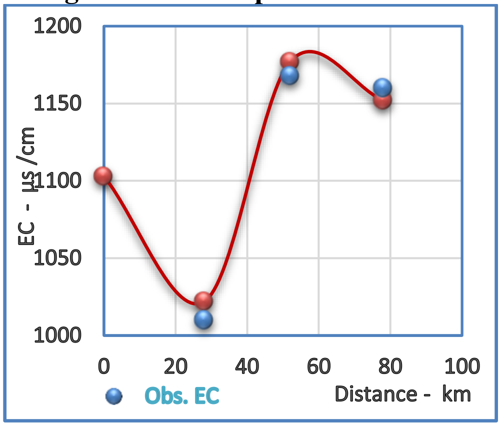

Fig. 14. Obs. – Sim. (EC) VS. Distance

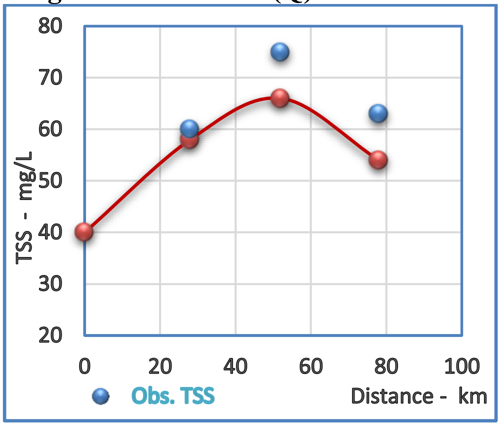

Fig. 15. Obs.- Sim. (TSS) VS. Distance

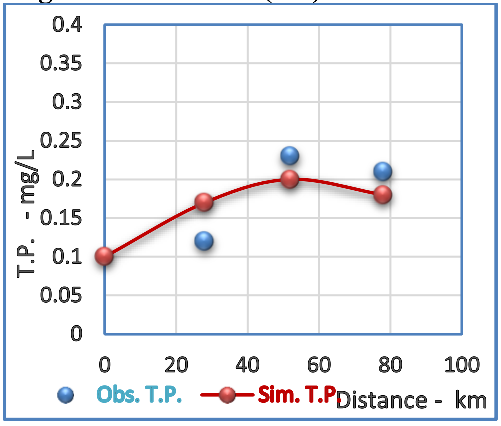

Fig. 16. Obs. - Sim. (T.P.) VS. Distance

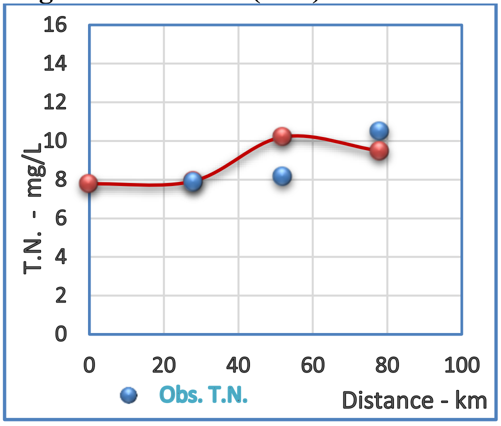

Fig. 17. Obs.- Sim. (T.N.) VS. Distance

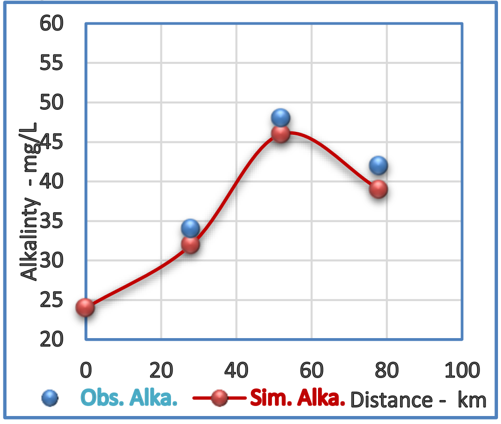

Fig. 18. Obs. – Sim. (CaCO3) VS. Distance

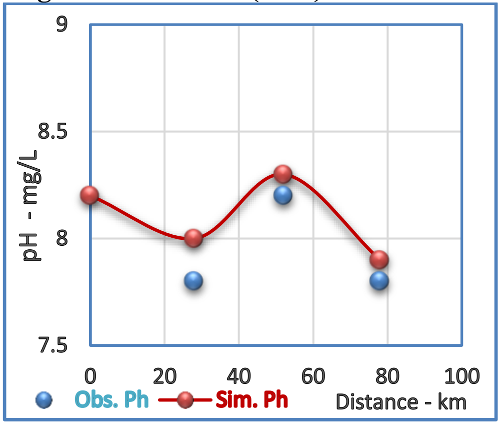

Fig. 19. Obs. and Sim. (pH) VS. Distance

4.2. Statistical tests for the first and second rounds (calibration-validation)

For first round (calibration) and second round (validation), the statistical tests applied to check the model suitability in simulating the quality parameters concentrations for the Euphrates River, such as Relative Error and Root Mean Square Error (Hussien, 2017; Hodson, 2022). These tests were applied between each of the simulated data from run of the model, and observed data from the sites for quality parameters (EC, TSS, pH, Alkalinity CaCO3, TN, and TP). In the (RE) test, the values of the results for all quality parameters close to zero, also the values in the two periods close together means acceptable. For (RMSE) test, the results values lies between zero to two or nearest which are in normal range, and the results in two periods close together which means acceptable (Draxler, 2014). The results of these tests are listed in Table 7. Generally; the statistical results showed agreement and big convergence between the simulated values and the observed values in both periods, which generates confidence and reassurance for adopting the model application in simulating the of water parameters concentrations.

Table 7: Statistical test results in two rounds.

Parameter	R.E.		R.M.S.E.	
	Calibration	Validation	Calibration	Validation
EC	0.05019	0.07207	8.7607	9.1924
TSS	0.12875	0.09905	9.083	6.7454
pH	0.02759	0.01571	0.2398	0.1323
Alkalinity (CaCO3)	0.08519	0.06381	3.0414	2.2813
T. N.	0.06052	0.09583	1.0388	1.695
T. P.	0.2751	0.29749	0.0579	0.0312

4.3. Strategies for control of Dead Storage Releasing:

According to the results of statistical tests that gave acceptability for applying this model to the Euphrates River within study area. In this section, an evaluation was conducted to show the extent of the impact of dead stored water releases from the Tharthar reservoir on the quality and concentrations of water parameters of the Euphrates River from the intersection point of the Tharthar Arm Canal with the Euphrates River and along the distance to central of Iraq. The software of the QUAL2KW model was run with different scenarios represented by different releases of water discharges from the Tharthar reserve with increases by (30% , 60% and 100%) shown in Figs. (20-25) and compared the results of parameter concentrations with the upper limit for drinking and irrigation purposes (water quality standard) (NEPA, 2018) for each parameter, arriving at the suitable scenario for operation, by determining the optimal ratio between the amount of water that is released from Tharthar reservoir to the amount of water released from Ramadi Barrage, leading to determining the highest discharge that can be released from Tharthar Lake and the value of the concentrations of each parameter which is not exceed the standard specifications of an upper limit for different purposes.

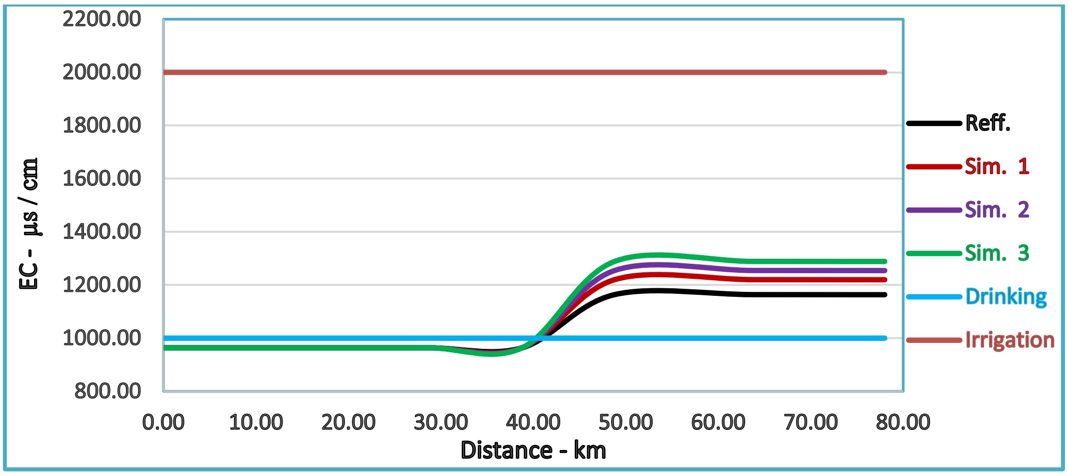

Fig. 20. Concentration of (EC) with the different scenarios of Tharthar reservoir discharge releasing, and upper limit for drinking and irrigation purposes

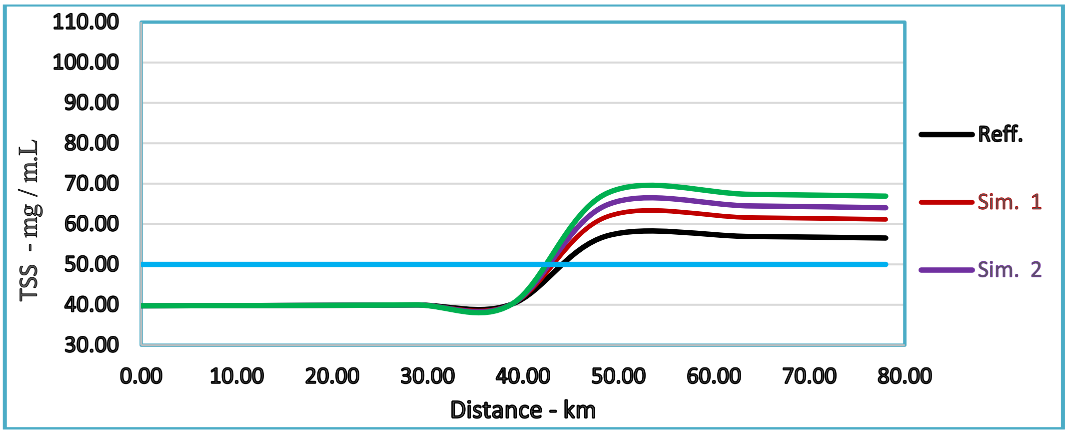

Fig. 21. Concentration of (TSS) and upper limit for drinking purposes

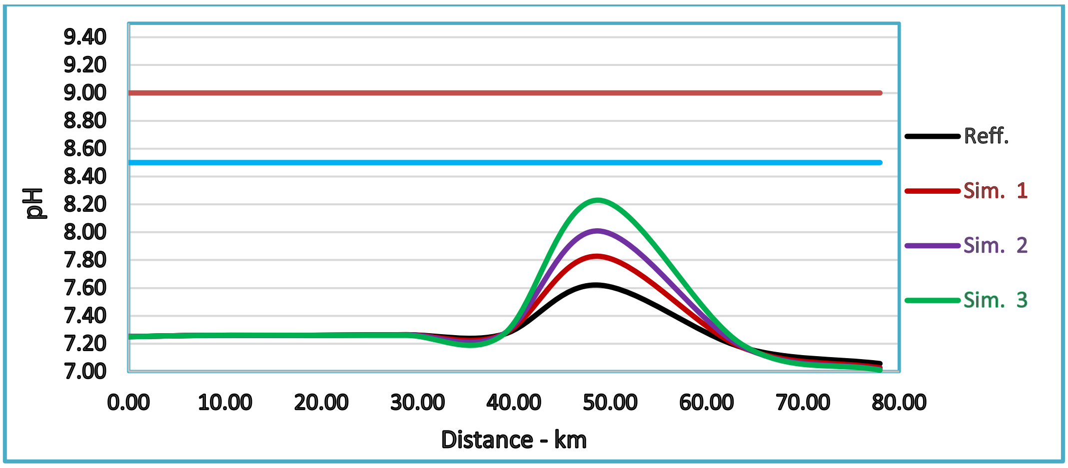

Fig. 22. Concentration of (pH) and upper limit for drinking and irrigation purposes

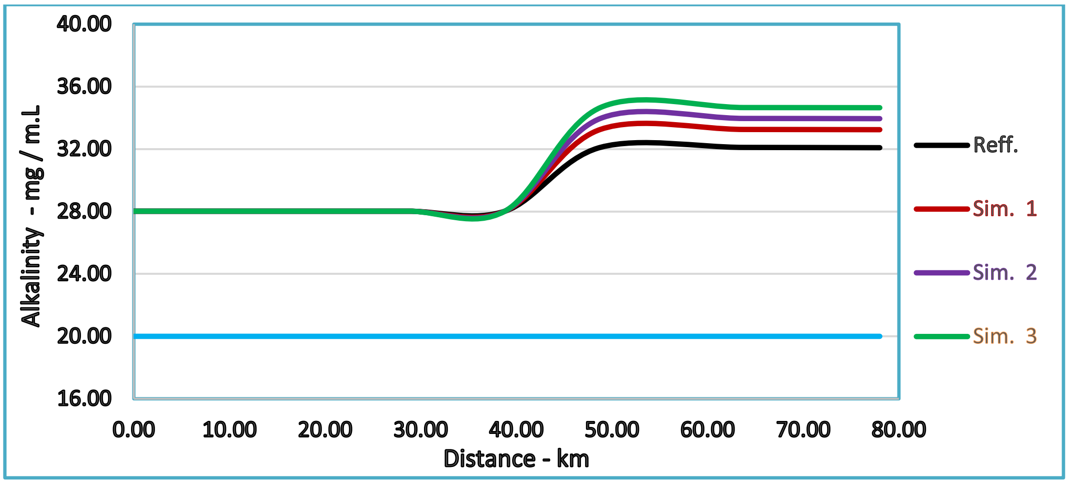

Fig. 23. Concentration of (CaCO3) and upper limit for drinking purposes

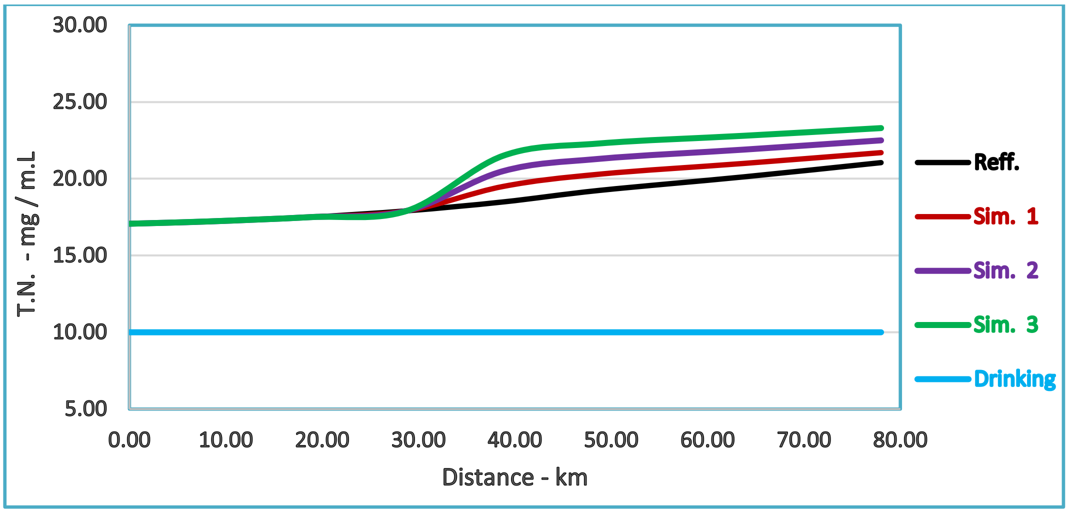

Fig. 24. Concentration of (T.N.) and upper limit for drinking purposes

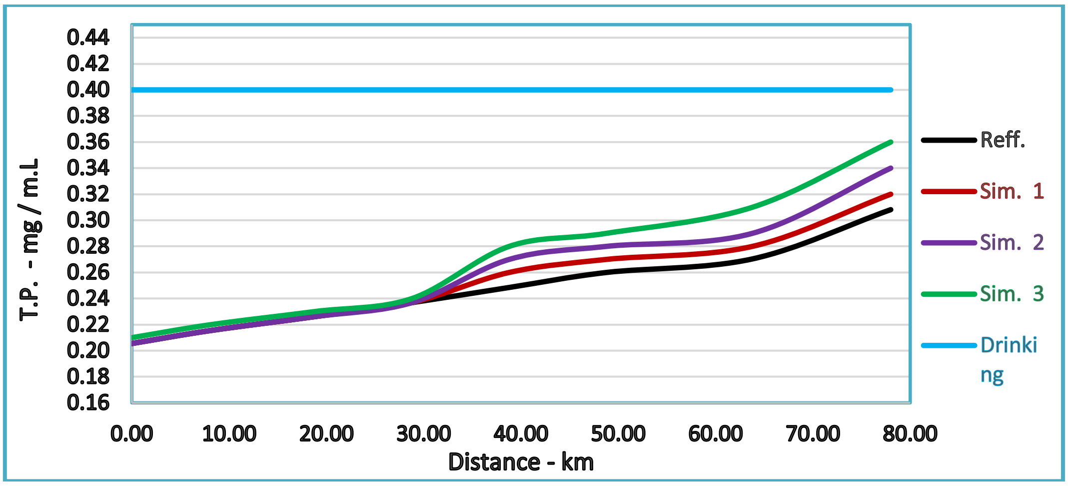

Fig. 25. Concentration of (T.P.) and upper limit for drinking purposes

For the three scenarios, and when the discharge of Tharthar reservoir (QTha.) is increased by 30%, 60%, and 100%, the ratio of discharge release between the Tharthar reservoirs to Ramadi Barrage (QTha. /QRam.) it becomes 65%, 80% and 100.1% respectively as shown in Table 8 and Table 9. To analyze the results of parameter concentration due to the three scenarios. For the electrical conductivity parameter (EC), and according to these scenarios, the concentration ratio increases by 5%, 8%, and 11% respectively, and these concentrations lie above the line of suitability for drinking purposes (1000 µs/cm) and below the line of suitability for irrigation purpose (2000 µs/cm) (NEPA, 2018), that's mean the river water quality still within the standard condition for irrigation purpose, and need for some treatment to be used in drinking. For the Total Suspended solids parameter (TSS), and according to these scenarios, the concentration ratio increases by 9%, 14%, and 19%, respectively, and these concentrations lie above the line of suitability for drinking purposes (50 mg/l) that's mean the river water quality need for treatment to be used for this purposes. For the hydrogen ion parameter (pH), and according to these scenarios, the concentration ratio increases by 3%, 5%, and 8% respectively, and these concentrations lie below the line of suitability for drinking purposes (8.5) and below the upper limit for irrigation purposes (9.2) that's mean the river water quality doesn't need for treatment to be used in both purposes. For total alkalinity parameter (CaCO3), and according to these scenarios, the concentration ratio increases by 4%, 6%, and 8% respectively, and these concentrations lie above the line of suitability for drinking purposes (20 mg/l) and below the upper limit for Irrigation purposes (200 mg/l), that means the river water needed for some treatment to be used in drinking. The total nitrogen parameter (T.N.), and according to these scenarios, the concentration ratio increases by 3%, 7%, and 10% respectively, and these concentrations lie above the line of suitability for drinking purposes (10 mg/l), which means the river water needed for some treatment to be used in drinking. The total phosphorus parameter (T.P.) and according to these scenarios, the concentration ratio increases by 3%, 10%, and 16% respectively, and these concentrations lie below the line of suitability for drinking purposes (0.4 mg/l), that means the river water quality still within the standard condition for drinking. In summary, and for all quality parameters used in this study, the increase in Tharthar reservoir release by (30%, 60% and 100%) led to increases in these concentrations by (3% - 9%), (5% - 14%) and (8% - 19%) respectively, which does not significantly affect the quality of the Euphrates River's water.

Table 8: Quality parameters concentrations for current discharge and different scenarios.

Scenario	**Current (Q)**		**Sim. 1 Δ Q Tha. = 30 %**		**Sim. 2 Δ Q Tha.= 60 %**		**Sim. 3 Δ Q Tha. = 100 %**	
Parameter	**C max.**	**C min.**	**C max.**	**C min.**	**C max.**	**C min.**	**C max.**	**C min.**
EC. (µs./cm)	1163	963	1220	963	1254	963	1288	963
TSS. (mg /L)	57	39.7	62	39.7	65	39.7	68	39.7
pH	7.6	7.1	7.8	7.1	8.0	7.1	8.2	7.1
CaCO3 (mg /L)	32.1	28.1	33.26	28.1	33.96	28.1	34.66	28.1
T.N. (mg /L)	21.05	17.07	21.7	17.07	22.5	17.07	23.3	17.07
T.P. (mg /L)	0.31	0.21	0.32	0.21	0.34	0.21	0.36	0.21

Table 9: Ratio of quality parameters concentration for the different scenarios

Scenario	**Current QThi. / QRam. %**	**Sim. 1** **ΔQ Tha. = 30 %**		**Sim. 2** **ΔQ Tha. = 60 %**		**Sim. 3** **ΔQ Tha. = 100 %**	
Parameter		QThi. / QRam. %	Δ C	QThi. / QRam.%	Δ C	QThi. / QRam. %	Δ C
EC (μs/cm)	51	65	0.05	80	0.08	100.1	0.11
TSS (mg /L)	51	65	0.09	80	0.14	100.1	0.19
pH	51	65	0.03	80	0.05	100.1	0.08
Alkalinity (mg /L)	51	65	0.04	80	0.06	100.1	0.08
T.N. (mg /L)	51	65	0.03	80	0.07	100.1	0.10
T.P. (mg /L)	51	65	0.03	80	0.10	100.1	0.16

5. COCLUSIONS

1. The Qual2kw model can be applicable to use in simulation and estimation the concentration of Euphrates River quality parameters in the future periods after feeding the software of this model with all required data such as hydrologic data, hydraulic data, and information about the point sources that suppling the river without sampling from any sites which is need analysis in laboratory and requires cost, just take one sample from zero station at (0.00 km).
2. When the model was run with different scenarios of water releases (dead storage) from the Tharthar reservoir, and in the worst case, when doubling the amount of this water, the concentrations of water quality parameters increased by percentage value ranging from (8% to 19%), which does not significantly affect the quality of the river's water.
3. By analyzing the results of applying different scenarios for the discharges of the Tharthar reservoir, and ensuring that Euphrates River water quality is not greatly affected by this added water, the Ministry of Water Resources can pump large quantities from the dead storage water to the Euphrates River to compensate for the shortfall in its quantities and enhance water supplies to meet the requirements of the regions of central and southern Iraq.

6. REFERENCE

Abbas, A.A.A. and Hassan, F.M. (2018). Water quality assessment of Euphrates River in Qadisiyah province (Diwaniyah River), Iraq. Iraqi Journal of Agricultural Science, 49(2), 251-261.

Abed, B.S., Daham, M.H. and Ismail, A.H. (2021). Water quality modelling and management of Diyala River and its impact on Tigris River. J. Eng. Sci. Techno, 16(1), 122-135.

Al-Ansari, N., Ali, A. and Knutsson, S. (2014) Present conditions and future challenges of water resources in Iraq. Journal of Water Resource and Protection, 6(12), 1066-1098. http://dx.doi.org/10.4236/jwarp.2014.612102.

Albakri, M. and Hussien, D.S. (2017). Evaluating the Quality of Authoritative Geospatial Datasets. Journal of Engineering, 23(11). https://joe.uobaghdad.edu.iq/index.php/ main/article /view/366.

Al-Hashim, M.A.I. and Al-Mosewi, A.T. (2009). Studying of Heated Water Released from South-Baghdad Electric Station to the Tigris River. Journal of Engineering, 15(4). https://joe.uobaghdad.edu.iq/index.php/main/article/view/3157.

Al-Juhaishi, M.R., Fabrice, M. and Motelica-Heino, M. (2024). Frequency Analysis of the Loire River Water Total Suspended Solid and Electrical Conductivity (Orleans, France). IOP Conference Series:Earth and Environmental Science, 1374(1). https://doi:10.1088/1755-1315/1374/1/012071.

Brusseau, M. L., Walker, D. B., & Fitzsimmons, K. (2019). Physical-chemical characteristics of water. In Environmental and pollution science, 23-45. https://doi.org/10.1016/B978-0-12-814719-1.00003-3.

Chai, T. and Draxler, R.R. (2014). Root mean square error (RMSE) or mean absolute error (MAE) Arguments against avoiding RMSE in the literature, Geoscientific model development, 7(3), 1247-1250. http://doi:10.5194/gmd-7-1247-2014.

Chapra, S.C. and Pelletier, G.J. (2003). QUAL2K: a modelling framework for simulating river and stream water quality (beta version): documentation and user's manual. Civil and Environmental Engineering Dept., Tufts University.

Elliott, H.A., O'Connor, G.A., Lu, P. and Brinton, S. (2002). Influence of water treatment residuals on phosphorus solubility and leaching. Journal of Environmental Quality, 31(4), 1362-1369.

Ferreira, D.M., Fernandes, C.V.S., Kaviski, E. and Fontane, D. (2020). Transformation rates of pollutants in rivers for water quality modelling under unsteady state: A calibration method. Journal of hydrology. 585,124769. https://doi.org/10.1016/j.jhydrol.2020.124769.

Hadi, Z.A. and Al-Juhaishi, M.R. (2023). Water Quality of Tigris River in Mosul and Al-Amarah Cities by using CCME Water Quality Index. Journal of Engineering, 29(3),170-181. https://doi.org/10.31026/j.eng.2023.03.12.

Hashim ,K. and Abdulhadi, B. (2022). LABORATORY STUDY OF ELECTROCOAGULA- TION FOR COD REMOVAL FROM WASTEWATER. Kufa Journal of Engineering, 13(1), 102-108. https://doi.org/10.30572/2018/kje/130106.

Hashim, L.I. and Azzubaidi, R.Z. (2023). The Roughness Coefficient in Euphrates River Reach between Haditha Dam to Ramadi Barrage. Journal of Engineering, 29(3),117-124. https://doi.org/10.31026/j.eng.2023.03.08.

Hobson, A. (2013). Using QUAL2Kw as a decision support tool: Considerations for data collection, calibration, and numeric nutrient criteria. Utah State University. 2013.

Hodson, T.O. (2022). Root mean square error (RMSE) or mean absolute error (MAE): When to use them or not. Geoscientific Model Development Discussions, 1-10. https://doi.org/10.5194/gmd-15-5481-2022.

Kassir, M.G., Dawood, L.M. and Fuad, F. (2015). Quality assurance for Iraqi bottled water specifications. Journal of Engineering. 21(10), 114-132.

Khlaif, B.M. and Al-Hassany, J.S. (2023). December. Assessment of the Euphrates River's Water Quality at a Some Sites in the Iraqi Governorates of Babylon and Karbala. IOP Conference Series: Earth and Environmental Science, 1262(2), 02202. http://doi:10.1088/1755-1315/1262/2/022021.

Kori, B.B., Shashidhar, T. and Mise, S. (2013). Application of automated QUAL2Kw for water quality modeling in the river Karanja, India. Global Journal of Bio-Science and Biotechnology, 2(2).193-203.

Mahdi, A.K. and Azeez, N.M. (2024). A review of Water Quality and Pollution Assessment of the Euphrates River. Science, 5(4), 184-189.

Mueller, D.S., Wagner, C.R., Rehmel, M.S., Oberg, K.A. and Rainville, F. (2013). Measuring discharge with acoustic Doppler current profilers from a moving boat (No. 3-A22). US Geological Survey, http://www.usgs.gov/.

Mustafa, A.S., Sulaiman, S.O. and Shahooth, S.H. (2017). Application of QUAL2K for Water Quality Modeling and Management in the lower reach of the Diyala River. Iraqi J. Civ. Eng., 11, 66-80. https://ijce.journalpath.com/ijce/article/view/169.

NEPA. (2018). Water Quality Standard National Environment Protection Act (NEPA). United States Environmental Protection Agency.

Ojo, O., Sekunowo, I., Ilomuanya, M., Gbenebor, P. and Adeosun, S. (2021) Compositions and thermo-chemical analysis of bovine and caprine bones. Kufa Journal of Engineering, 12(3), 56-68. HTTP://DX.DOI.ORG/10.30572/2018/KJE/120305.

Tuozzolo, S., Langhorst, T., de Moraes Frasson, R.P., Pavelsky, T., Durand, M. and Schobelock, J.J. (2019). The impact of reach averaging Manning's equation for an in-situ dataset of water surface elevation, width, and slope. Journal of Hydrology, 578, 123866. https://doi.org/10.1016/j.jhydrol.2019.06.038.