Salinity Variation of Euphrates River between Ashshinnafiyah and Assamawa Cities

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ABSTRACT:

AshShinnafiyah and AsSamawa cities suffer from significant increase in salinity of Euphrates River water compared with their counterpart's north AshShinnafiyah city which is reflected adversely on the quality of water within the study area. The study aims to find possible solutions to avoid the deterioration of Euphrates River northern AshShinnafiyah city until AsSamawa city that were presented by total dissolved solid TDS. Twelve main hydrological and fifteen salinity measurement stations were selected to cover 117 *km* of the river reach within the study area during July-2011. Additional twenty three hydrological and salinity stations were adopted during March-2012, winter season to the river within the study area. After conducting the field and laboratory measurements, mathematical model using HEC-RAS v.4.1 software were implemented, using the available geometric and recorded and measured hydrological data. Eleven scenarios were adopted, by canceled one or more of the drains that cause the deterioration in the river, to find the best scenario using various discharges of Al Ya'uo Regulator (Upstream of study area), where the criteria are the water level at AsSamawa city (downstream boundary) is not less than 6 *m.a.m.s.l.* and the maximum acceptable salinity for agricultural purposes is 1500 *mg/l* according to Specification of Iraq No. 417 for maintenance of river pollution, 1967. It was concluded from both models that the problem of salinity in the study area cannot be avoided without diverting one or more of the drains that outfall in the river. The minimum instream flow MIF was found for each scenario. Euphrates River without Eastern Al-Jarah, Al-Khassf, AnNagara, and Al-Haffar Drains, and outfalls Between AshShinnafiyah and Garrb Villages, Scenario 9, is the best one, where it gave the minimum required discharge from Al-Ya'uo Regulator of 82m^3/s and 165m^3/s during summer and winter seasons respectively.

KEYWORDS: Salinity, minimum instream flow, Euphrates River, Al-Ya'uo Regulator, Scenario

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التغاير الملحي في مياه نهر الفرات بين مدينتي الشنافية و السماوة

الملخص:

تعاني مدينتي الشنافية و السماوة من زيادة ملحوظة بملوحة مياه نهر الفرات مقارنة بنظيرتها شمال مدينة الشنافية والذي ينعكس سلباً على نوعية مياه النهر ضمن منطقة الدراسة .تهدف هذه ألدراسة الى ايجاد الحلول الممكنة لتفادي التدهور الحاصل في ملوحة مياه نهر الفرات شمال مدينة الشنافية وصولا الى مدينة السماوة والمتمثلة بالمواد الذائبة الكلية TDS. تم تحديد اثنى عشر محطة هيدرولوجية و خمسة عشر محطة قياس ملوحة في مياه النهر لتغطي مسافة 117 كم من طول مجرى نهر الفرات والواقعة ضمن منطقة الدراسة في شهر تموز عام 2011 في حين تم رصد ثلاث وعشرون محطة قياس هيدرولوجية وبنفس العدد من محطات قياس ملوحة مياه النهر في شهر آذار عام 2012. بعد اجراء القياسات الحقلية والمختبرية، تم أعداد نموذج رياضي احادي البعد باستخدام البرنامج الجاهز HEC-RAS, v. 4.1 من خلال ادخال البيانات الهيدرولوجية المرصودة و كذلك المساحية المتوفرة والمتمثلة بالمقاطع العرضية الممتدة لمسافة 117 كم على طول مجرى النهر. واخيراً تم استخدام البيانات المتعلقة بالانواء الجوية في النموذج النوعي للمياه. تم افتراض أحد عشر سيناريو، والتي تتضمن إلغاء واحد أو أكثر من المبازل المسببة للتدهور الحاصل في ملوحة مياه النهر. من أجل أيجاد أفضل سيناريو تم أعتماد تصاريف مختلفة عند ناظم اليعو (مقدم منطقة الدراسة)، حيث كانت المحددات هي، أن منسوب المياه في مدينة السماوة (مؤخر حدود منطقة الدراسة) يجب ان لا يقل عن 6 متر فوق مستوى سطح البحر وان اقصى ملوحة مقبولة في مياه النهر ليلبي متطلبات الزراعة هي 1500 ملغم / لتر وفقا للمواصفة العراقية رقم 417 لصيانة الانهار من التلوث 1967. استنتج من هذين النموذجين الرياضيين استحالة تجنب مشكلة الملوحة في منطقة الدراسة دون تحويل واحد أو أكثر من المبازل التي تصب في النهر، وعليه تم احتساب الحد الأدنى للتصريف المطلوب لكل سيناريو، ووجد ان السيناريو الذي يتم من خلاله رفع مبازل الجارة الشرقي والنكارة والخسف والحفار والمصبات الواقعة بين مدينة الشنافية وقرية غرب و الذي يمثل السيناريو رقم 9 هو افضل سيناريو مقترح، كونه يتطلب اقل كمية مياه مطلوبة مطلقة من ناظم اليعو والتي هي 82 م3/ثا و 165 م3/ثا لفصلي الصيف والشتاء على التوالي.

كلمات رئيسية:

الملوحة، الحد الادنى للتصريف، نهر الفرات، ناظم اليعو، سيناريو

INTRODUCTION

The Euphrates River south of Al Kifil is divided into two main branches (Al Kufa and AshShamiyah) as illustrated in (Fig.1). Later, the channel splits again about 25 *km* upstream AshShinnafiyah and rejoins near AsSamawa. Then the river enters Al Hammar marsh, where it forms two main channels within Al Hammar marsh. One of the channels (northern) joins the Tigris River at Qurna forming what is known as Shat Al Arab River while the other channel join Shat Al Arab River at Karmat Ali, (Al-Ansari and Knutsson, 2011). The Euphrates River between AshShinnafiyah and AsSamawa Cities is suffering from extreme increase of salinity; where water reaches AsSamawa city with high salinity compared with that northern AshShinnafiyah City "Downstream Al-Ya'uo Regulator". Euphrates River downstream Al-Mishkhab Regulator divides into two branches. The right branch is called Al-Atshan River and is controlled by Abu-A’shrah Regulator, while the left one is AsSbeel River (which is the main stream of Euphrates River) and controlled by Al-Ya'uo Regulator, see (Fig.1). The salinity of Euphrates River before two the branches is much less than its value after the confluence of the two branches, especially upstream AsSamawa City. The salinity is more than double its value northern AshShinnafiyah City because the waters of AshShamiyah, Mishkhab, and AshShinnafiyah irrigation projects are drained into the main stream of Euphrates River "AsSbeel River". Moreover, the inflow of waste water and interflow form the upstream confluence of AsSbeel and Al-Atshan Rivers cause additional deterioration in water of Euphrates River in the area. The reduction in the annual inflow of Euphrates River is one of the main factors that cause the deterioration of the water quality in the river; especially within the reach of the study area which is located downstream of AshShinnafiyah Town. Since the water quality, deterioration of Euphrates River in study area may be affected by the surface and/or subsurface water sources within the region of the study area.

Hydrology of Euphrates River

Many studies concerned with hydrology of Euphrates River had been done.

(Kolars, 1994, and, Beaumont, 1998), mentioned that the total annual stream flow of the upper Euphrates, across the Turkish/Syrian border, between"1937-1973" (prior to the construction of major dams) ranged between a minimum of 16.8 *billion m3* (1961) to a maximum of 53.5 *billion* m^3 (1969). The GAP is a Turkish irrigation-agricultural project that depends on the Euphrates and the Tigris Rivers for its water supplies. The project involves, among others, the construction of 21 dams and reservoirs on the Euphrates and Tigris Rivers. (Partow, 2001), prepared a report "The Mesopotamian Marshlands: demise of an ecosystem", where it is stated the flow of the Euphrates is highly regulated and controlled by a series of dams and reservoirs constructed by Turkey, Syria, and Iraq . In 1975, the Turkish Kuban and the Syrian Tabqa dams began operation. Two years later, Turkey's Southeast Anatolia Project ''Guneydogu Anadolu Projesi'' (GAP) was initiated. As of 1997, the total storage value of all the dams that had been constructed on the Euphrates in Turkey was 90.9 *billion* m^3 and it will reach 94.78 *billion* m^3 when all of the GAP works completed. This storage capacity is about three times the 30.7 *billion* m^3 average annual river's flow. In Iraq and Syria, the combined storage capacity of all dams was 22.88 *billion* m^3. Adding this figure to the Turkish reservoirs capacity makes the gross storage capacity of all existing hydraulic structures on the Euphrates 117.66 *billion* m^3. This storage capacity is about four times the river's average annual flow. (Consulting Engineering Bureau, 2011), prepared a report "Tigris and Euphrates Sampling", this study comprises collecting water samples from upstream, mid-country and southern Iraq locations for each of the Tigris and Euphrates Rivers. Water sampling points along Euphrates River were at Al Qaim, AsSaklaowea, and AnNasiriya. These three points along each River were specified and agreed by the Ministry of Water Recourses, MoWR, representative. The headwaters of the river are at elevation of about 3000 to 3500 *m.a.m.s.l*, and its end at Al Qurna is about a few meters above the mean sea level, (Fig.2). There is only one dam on Euphrates River that has constructed for the purpose of storing, regulating and providing water for irrigation, and to generate hydroelectricity, that is Haditha Dam. The MoWR is planning to construct small dams on wadies that seasonally discharge their water into the Euphrates River within the west desert to control and to store their flood flow of these wadies and its tributaries. Barrages were constructed on the main water column of Euphrates River upstream, to maintain sufficient water level to provide water for rivers and canals branching at the upstream. The Iraqi water strategy is highly influenced by the Euphrates water as more than 90% of its flow comes from outside the country. Iraq is supposed to receive 58% of the Euphrates flow, which crosses the Turkish- Syrian border, while Syria receives 42% according to mutual agreement between the two countries. Turkey promised in the past to secure minimum flow of 500 m^3/s at its border which gives Iraq 285 m^3/s. Up to now, there has been no agreement between the three countries concerning the Euphrates and Tigris Rivers water.

Water Quality of Euphrates River:

Water quality control is an important protection issue. The analysis of the existing water quality parameters and trend of their change is useful for making quantitative decision, such as whether water quality is improving or getting worse over the time. These decisions are important in planning of water pollution control program. Historically, the Euphrates waters had low salinity.

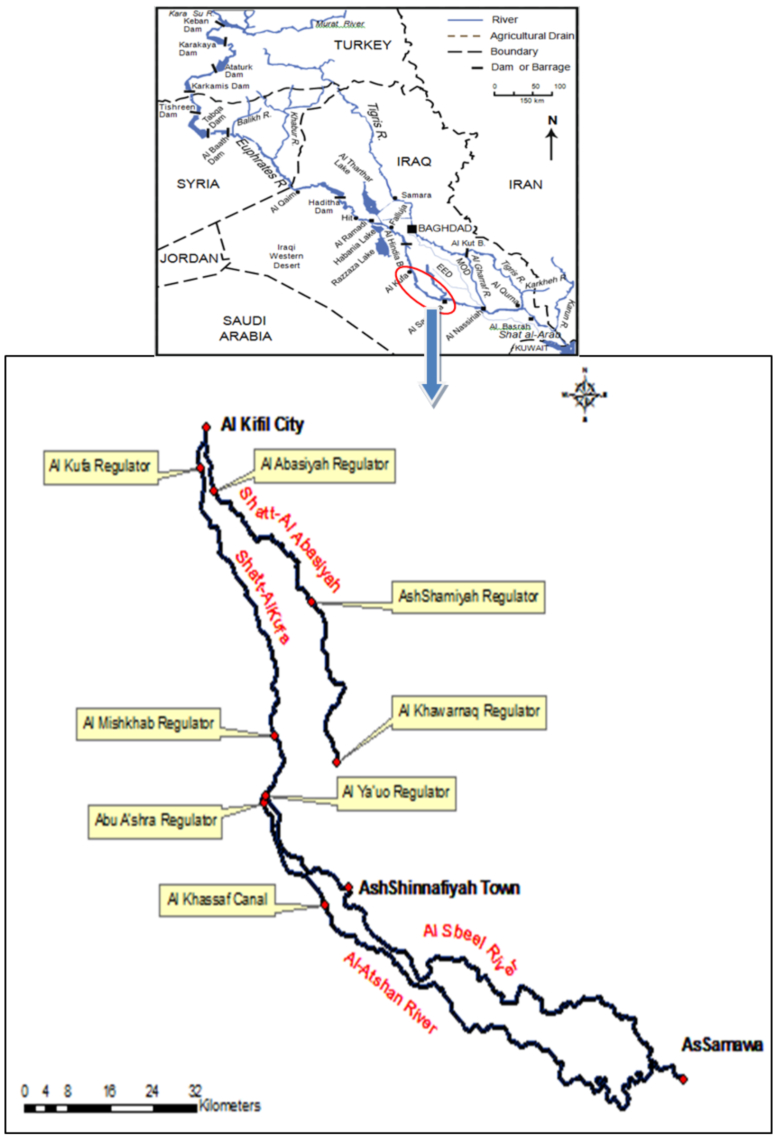

Fig.1. Location of the study area.

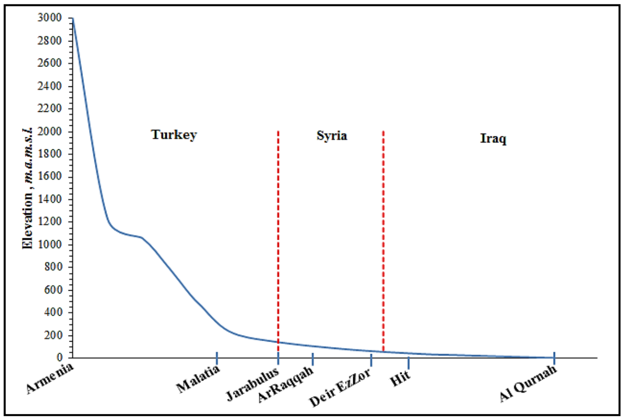

Fig. 2. The longitudinal section along Euphrates River, after Consulting Engineering Bureau, 2011.

At the Keban gauging station, Turkey, the TDS was 261 *ppm* as reported by (Scheumann 1993). It was classified as C2S1 (water with medium salinity and lower concentration of sodium), which is suitable for irrigation. At Al Qaim station, where the river enters Iraq as shown in (Fig. 1), the TDS was 467 *ppm* in 1970 (Hanna and Al Talbani 1970). Fattah and (Abdul Baki, 1980) studied the effect of drainage water on the Euphrates water quality. Their study concluded the influence of agricultural drainage disposal on the quality of the Euphrates River water between Al Hindiya and AshShinnafiyah (a town located on the river just upstream from AsSamawa) is remarkably significant and may explain the major portion of the increase in concentration of TDS along that reach. He mentioned that the TDS at Hit had increased from less than 500 *ppm* to about 700 *ppm*. By 1989, the Euphrates salinity at Al Qaim reached 1,000 *ppm*, (Al-Najim 2003). salinity values of greater than 2,000 *ppm* at AsSamawa and exceeded 3,500 *ppm* at An Nasiriya were published for two periods (1974–1978, and 1998–2002), (Fattah and Abdul Baki 1980; Ministry of Irrigation, 1998; Ali and Salewicz, 2005). Additionally, they stated the increase in concentration of TDS between Hit and Al Nasiriya occurs between Al Hindiya and AshShinnafiyah with a second major increase in concentration between AshShinnafiyah and AsSamawa. (Al-Eoubaidy, 1999) presented study is concerned the development of a dynamic water quality model in Euphrates river to simulate water quality constituents for inorganic pollutants which are conservative in nature, and their handling depends mainly on ability to model the mixing mechanics of the receiving body of water. Traditionally total dissolved solids (TDS) and Sulphate (So_4^{-2}) has used as principal indicators of water quality variations in Euphrates River within (Ramadi-Hindiya) reach. The model contained two parts, the first is a hydrodynamic model, and the second is a quality model, one-dimensional numerical model (hydrodynamic model) has presented for simulating the one-dimensional nonlinear partial differential equations (Saint-Venant). The quality model is a based on the one dimensional convective dispersion equation for conservative substance. The quality model applied to idealized cases and verified by comparison with analytical, explicit, and implicit solutions. To study the effect of different parameters depth, velocity and lateral dispersion coefficient on the mixing process. A two dimensional convective dispersion equation for steady and unsteady state is present using explicit and finite element method. (Al Tai, S.A., 2001) shown that the water quality of Al Qadissiya dam and Al-Habaniya lake are influenced by the quality of the water that reaches Iraq-Syrian border, where the expected TDS reaches 1297 *ppm* in Al Qadissiya Dam when the upstream countries take their full water needs with the existence of returned water; this result will influence the quality of water in Iraq. Additionally, the practical deterioration just before AsSamawa City could be attributed to the badness of the drainage water quality of Western AshShamiyah, Eastern AshShamiyah, Al Khassf Drains and the water quality in the rear of Abu-A'shrah regulator, which contribute obviously to the increasing of salt concentration for the lower reach of Euphrates River. (Tikriti, 2001), used stochastic models to forecast the discharges and hydrochemical parameters in Euphrates River. The searcher select two stations for the analysis and modeling that are at Al Hindiya Barrage and AsSamawa City. The selected hydrochemical parameters are Electrical Conductivity, Total Dissolved Solids, Calcium, Magnesium, Chloride, Sulfates and Total Hardness. The study concluded that the reduction in the inflow of Euphrates River, affects the water quality in this river. The study predicted that further decreasing of the average flow from 100-200 m^3/s to 50-100 m^3/s in Euphrates River would result in general increase in the concentrations of the hydrochemical parameters. The maximum percentage increase in the concentrations will be 4.31% for TDS and 27.9% for So_4 which indicates that the rate of increase of So_4 will be greater than that of TDS. (Rahi, 2002), studied the Deterioration of the Euphrates water quality downstream of Al Kufa Barrage. He mentioned that during 2002, the Iraqi Ministry of Irrigation, measured TDS for the reach that extends from Al Kufa to AnNasiriya. The analysis showed that the TDS was 1100 *ppm* near Al Kufa, increased to 4000 *ppm* at AsSamawa and attained 5000 *ppm* at AnNasiriya, as shown in (Fig.3).

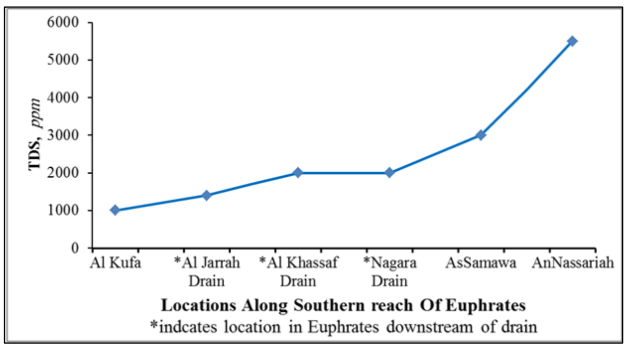

Fig.3. TDS in the Euphrates in 2002, after Rahi 2002, re-edited.

(Ali and Salewicz, 2005), showed that the salinity along Euphrates River has increased from 500 *ppm* to more than 4500 *ppm*, and published the salinity profile along the river from Al Qaim to AnNasiriya for the water year 2000–2001. The measured salinity is 1000 *ppm* in Al Qaim, 1100 *ppm* in Al Hindiya, 3000 *ppm* in AsSamawa and 4000 *ppm* in AnNasiriya. Available temporal records of salinity at Al Fallujah station (385 *km* from the Syrian border) show that the TDS ranged from 420 to 710 *ppm* during the period of 1959 - 1973 as shown in (Fig.4), (Al Hadithi 1978). The recorded salinity values are greater than 2000 *ppm* at AsSamawa and 3500 *ppm* at AnNasiriya as published for the two periods (1974–1978, and 1998–2002), as shown in (Fig.5). (Rahi, K., A. and Halihan, T., 2009), studied changes in the salinity of the Euphrates River system in Iraq, They concluded that the salinity of the Euphrates in Iraq has increased due to the decrease in quantity and the increase in salinity of the flow that is entering the country, the recharge to the river from Al Tharthar Lake, and irrigation return flows within Iraq. They showed that the salinity at the lower reaches of the river have increased to a point at which the river water is no longer useful for most municipal or agricultural purposes. They suggested applying the concept of minimum instream flow, MIF, or environmental flow, as a measure to improve the water quality and to preserve the environment of the river. An environmental flow rate of 178 m^3/s was calculated as the minimum flow that must be sustained to improve the water quality and to preserve the environment of the Euphrates. This flow maintained from Al Qaim to Al Qurna where the Euphrates meets the Tigris River. A flow of twice this amount would allow some minimum flexibility in managing salinity downstream from the border. They concluded that the TDS of the MIF as it enters Iraq at Al Qaim could be improving by managing irrigation return flow upstream of Iraq. Furthermore, eliminating the diversion of water to the Euphrates from Al Tharthar Lake will decrease the salinity of the Euphrates, but this quantity of water would need to be replacing at the Syrian border. Diverting the irrigation return flow from the river system to the Euphrates–Tigris Main Outfall Drain system could improve the salinity, but further study is required to access the impacts in the lower reaches of the river. (National Center for Water Resources Management of the MoWR, 2010), carried out evaluation of annual water quality studies of the main rivers during 2010. Water samples were collected at sixteen water sampling stations along Euphrates River from Al Qaim that is located near the location at which the Euphrates River crosses the borders to Al Qurna City where Euphrates River Joint Tigris River to form Shatt Al Arab River.

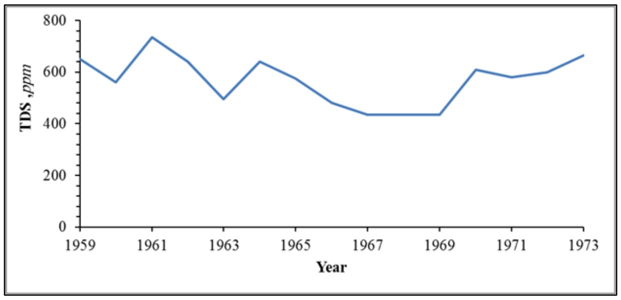

Fig. 4. Mean annual Total Dissolved Salts at Fallujah Gauging Station, after Al-Hadithi 1978, re-edited.

They noticed that the So_4^{-2} concentration is sometimes higher than the acceptable limit for irrigation use especially at the southern part of Euphrates River. Cl concentrations are some times higher than the acceptable limit. It has severe effects on plants from AshShinnafiyah to Al Qurna. While about the TDS values, they concluded that there was severe degree of restriction on use from AshShinnafiyah down to Al Qurna.

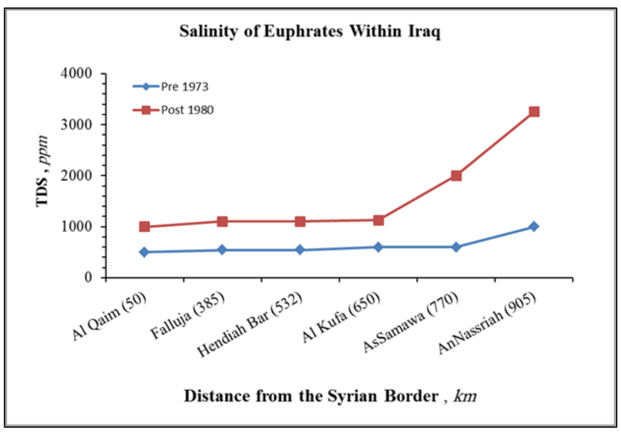

Fig. 5. Salinity along the Euphrates course prior to 1973 and after 1980, after Ali and Salewicz, 2005, re-edited.

(The National Center for Water Resources Management, 2011), carried out a water quality evaluation study on the Euphrates River reach between Al Kifil and AsSamawa, a weekly water sampling was carried out for a period from Oct. 31 to Dec. 31, 2010. Twelve sampling stations were selected along Euphrates River reach and the main drains that discharge their water directly to the river reach. Each water sample was analyzed for pH, EC, TDS, total hardens, Ca, Mg, K, Cl, So_4^{-2}, HCO_3, CO_3, NO_3, COD, and for number of trace elements including B, Fe, and Cr. The study concluded that the TDS concentration values at Euphrates River at Kifil, Al Mishkhab, and Gammas are less than 1000 *mg/l*. So, the water is suitable for drinking and irrigation. TDS concentration increased suddenly upstream AshShinnafiyah due to the water discharge of Al Haffar and Eastern and Western AshShamiyah drains. Euphrates River water is not suitable for drinking and irrigation at downstream AshShinnafiyah due to high TDS and the values of sodium adsorption ratio. More than three million people living in Diwaniya, AshShinnafiyah, AsSamawa, and AnNasiriya are suffering the bad water quality of Euphrates River reach under consideration. Moreover, the study concluded that $Na_2So_4^{-2}$ the main dominations within Euphrates River reach. Harmful concentration of boron on human and plants had been found at the study area. The significant negative effects on the ecological system are clear and cause reduction in the number of fishes.

DESCRIPTION OF STUDY AREA

The study area is located southern of Al Kifil city when Euphrates River is divided into two branches, the right one that flows' crossing Al Kufa, Mishkhab, and Al Qadissiya cities is known as Shatt Al-Kufa which is the main stream of the river. Shatt Al Kufa is divided into two branches, the left one, that flows' crossing AshShinnafiyah , Garrb, Al Bassamiya, and Al Hillal villages is known as AsSbeel River which is the main stream of the river where controlled by Al-Ya'uo Regulator. The other branch is known as Al-Atshan River, it's controlled by Abu- A'shrah Regulator. The confluence of Two branches is northern AsSamawa city, (523445 m, E – 3466300 m, N) UTM coordinates. Many drains, water intakes and outfalls are located within the study area. During the first field investigations trip, any changes were observed, we found that the channel which connects the second branch southern Abu-A'shrah regulator with the main branch of the river has been canceled. Also it was found that the feeding channel that is branched from the main stream (AsSbeel River) to Al Atshan branch at Al-Garb village was closed, as shown in (Fig.6).

SELECTION OF HYDROLOGICAL AND WATER QUALITY STATIONS:

The field investigations for the causes of water quality deterioration in Euphrates River downstream Al Kifil till AshShinnafiyah cities were achieved during June 2011.

Water samples were taken from 13 stations along Euphrates River reach between Al Kifil and AshShinnafiyah cities. The results of laboratory samples tests showed that the water quality of the Euphrates River upstream AshShinnafiyah town has the worst quality, specially the salinity of water. Accordingly, the study area under consideration was Euphrates River reach that is located between km 718 of Euphrates River (southern Al Ya'uo regulator) down to AsSamawa city at km 835. The study area is highlighted as red ellipse in (Fig.6).

FIELD MEASUREMENT:

Two sets of hydrological and water quality stations were done to calibrate and verify the hydraulic and water quality models of Euphrates River within the study area. The first hydrological and water quality sets was achieved during summer, (24-26/7/2011) while another set was achieved during winter, (5-8/3/2012).

SUMMER HYDROLOGICAL AND WATER QUALITY MEASUREMENTS (24-26/7/2011):

Twelve stations were selected to be discharge measurement stations. Discharges have been measured by Acoustic Doppler Current Profiler (ADCP). As well as the GPS device was used to identify observation sites on the river, and outfalls. Then the discharge at each observation point had been recorded and shown in (Table 1).

Table 1. Measured discharges of Euphrates River and some drains outfalls within the study area during Summer Season.

No.	Station Name	Coordinates		Discharge, m^3/s	Date
		Easting, *m*	Northing, *m*		
1	Eastern Al Jarah Drain	454210	3505096	25.83	24/7/2011
2	Euphrates River after Eastern Al Jarah	453620	3504405	42.83	24/7/2011
3	Euphrates River before Al Khassf Drain	451961	3493765	44.47	24/7/2011
4	Euphrates River before AnNagara Drain	460223	3497001	55.27	25/7/2011
5	Euphrates River after AnNagara Drain	461390	3496550	115.10	25/7/2011
6	Al Haffar Drain	463170	3496366	1.40	25/7/2044
7	Euphrates in AshShinnafiyah City	466460	3493984	118.60	25/7/2011
8	Euphrates River in Garrb village	480937	3480140	114.16	25/7/2011
9	Euphrates River in Al Majed region (before Al Atshan confluence)	520509	3470508	109.00	26/7/2011
10	Al Atshan River	522596	3465380	24.00	26/7/2011
11	Euphrates River after confluence	524728	3465730	133.00	26/7/2011
12	Euphrates River in AsSamawa City	527895	3464570	123.00	26/7/2011

The discharge measurements before and after the intakes and drains outfalls and the collected information's from the water resources directorates within the study area make possible the calculation of their discharges . The calculated discharges of the drains and intakes using continuity equation are shown in (Table 2). The scheme of the Euphrates River within the study area with all intakes and drains outfalls is shown in (Fig. 7).

Table 2. Calculated Discharges of Euphrates River, intakes and drains outfalls in the study area during Summer Season.

Stations	Coordinates		Discharge m^3/s
	Easting, *m*	Northing, *m*	
Al Ya'uo Regulator	451176	3508246	17.00
Gammas Outfall	457558	3499091	1.64
Al Khassf Drain	458793	3496537	9.53
AnNagashiya outfall	460223	3496975	1.27
AnNagara Drain	460304	3498103	59.83
Water Intakes U/S AshShinnafiyah (Aal-Shibel)	-	-	-6.90
Group of outfalls on Euphrates River (U/S AshShinnafiyah)	-	-	9.00
Water Intakes between AshShinnafiyah and Garrb Villages	-	-	-10.80
Group of outfalls and drains on Euphrates River between AshShinnafiyah and Garrb Villages	-	-	6.36
Water Intakes within (Aal A'lwaan) region	-	-	-8.00
Group of outfalls and drains on Euphrates River	-	-	4.50
Water Intakes (Aal A'lwaan) region	-	-	-1.60
Water Intakes U/S AsSamawa City	-	-	-10.00

- *The negative sign mean water intake.*

The second set of field work data gathered during the summer season is the water quality measurements. Fifteen stations were selected as water quality sampling points on the stream and on many drains outfalls that were easy to reach. The observations of water quality of these sampling points are shown in (Table 3).

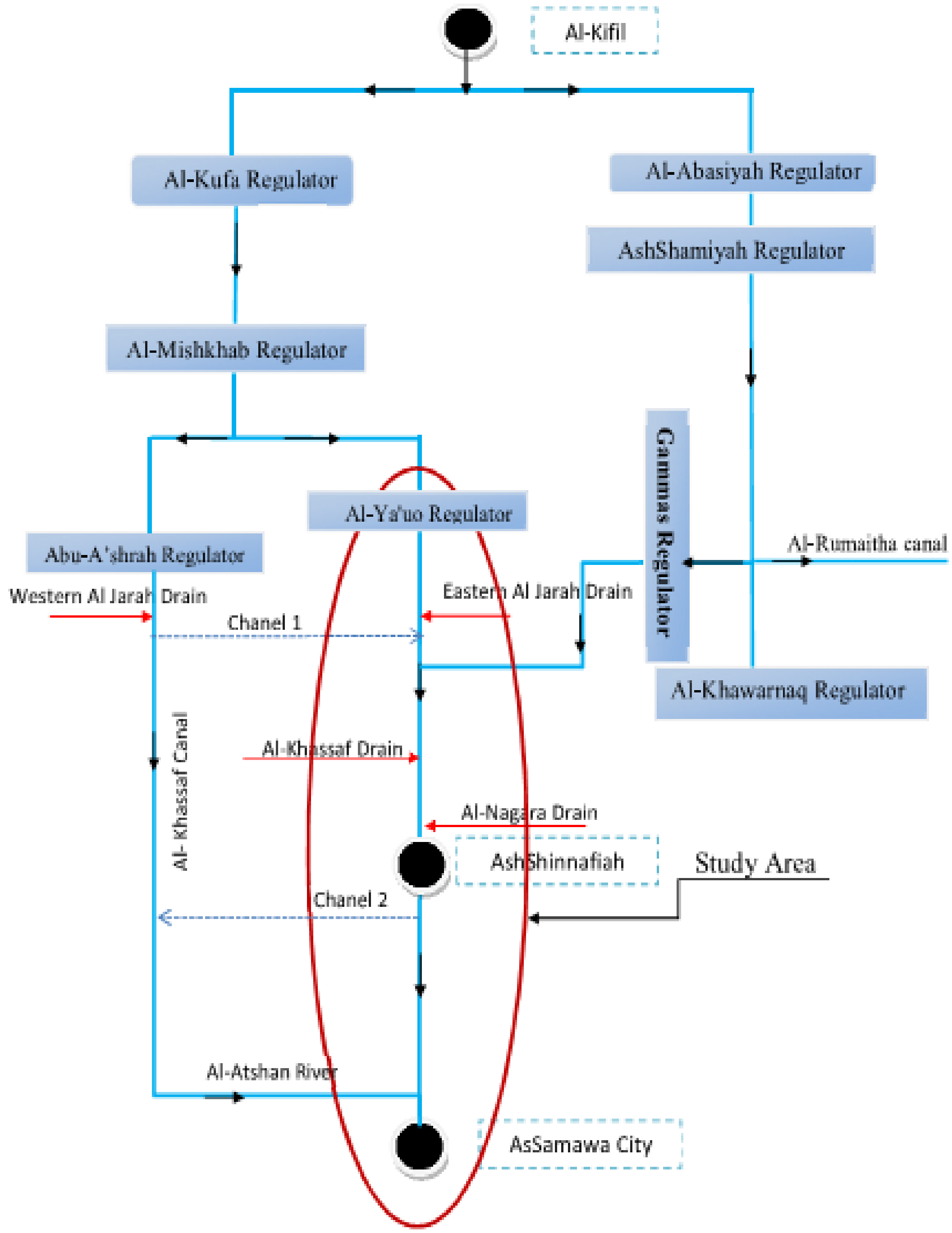

Fig. 6. Scheme of Euphrates River between Al Kifil and AsSamawa Cities

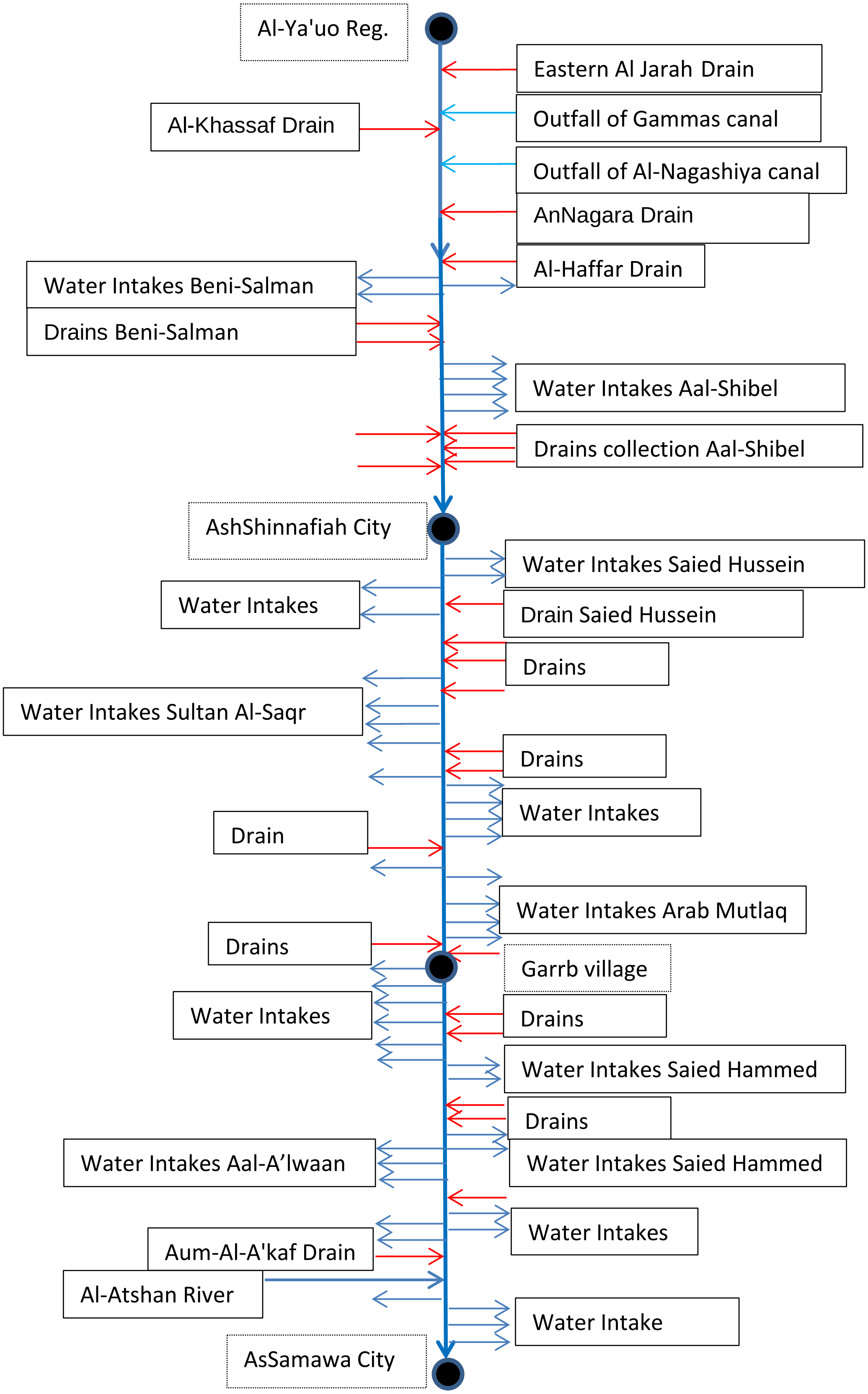

Fig.7. Schematic diagram of Euphrates River within the study area.

Table 3. Names of water quality sampling points, coordinates and results of field and laboratory measurements during summer season

Stations	Coordinates		EC, *µS/cm*	TDS *ppm*	pH	Water Temp. *C°*	Date
	Easting, *m*	Northing *m*					
Eastern Al Jarah Drain	454210	3505096	3000	2106	7.6	33.5	24/7/2011
Euphrates after Al Jarah drain	453620	3504405	2210	1570	7.7	33.0	24/7/2011
Gammas Outfall	457558	3499091	3200	2254	7.6	33.0	24/7/2011
before Al-Khassf Drain	451961	3493765	2950	2030	7.7	33.0	24/7/2011
Al-Khassf Drain	458793	3496537	4700	3620	7.9	34.0	24/7/2011
AnNagashiya outfall	460169	3497047	3640	2700	7.6	33.5	25/7/2011
before AnNagara Drain	460223	3497001	3510	2466	7.7	33.0	25/7/2011
AnNagara Drain	460304	3498103	4610	3450	7.5	34.0	25/7/2011
after AnNagara Drain	461390	3496550	3950	2700	7.6	33.0	25/7/2011
Al-Haffar Drain	463491	3496989	4600	3400	7.9	34.0	25/7/2011
Euphrates in AshShinnafiyah City	466460	3493984	3750	2600	7.7	32.0	25/7/2011
Euphrates River in Al-Garrb village (AsSbeel River)	480937	3480140	4130	2772	7.6	32.5	26/7/2011
Euphrates before Al Atshan confluence	520509	3470508	4300	2900	7.5	32.0	26/7/2011
Al Atshan River	522596	3465380	2400	1854	7.7	30.0	26/7/2011
Euphrates River in AsSamawa City	527895	3464570	4120	2762	7.6	32.0	26/7/2011

Winter hydrological and water quality measurements (*5-8/3/2012*):

The number of hydrological and water quality stations during winter season were taken more than that in Summer in order to investigate the location of interflow interface with the river if exist. The main reasons to study interflow effect are the low water levels in Euphrates River during winter, because of limited discharges in the river, and the recharge of the interflow from nearby region. The added stations are labeled with * in the below tables. Twenty three stations were selected to be the discharge measurement stations. The measured discharges in the stations are listed in (Table 4). The calculated discharges, as mentioned in the previous section, at the outfalls of some drain and of the intakes are listed in (Table 5).

Twenty three stations were selected as water quality sampling points on the stream and on many drains outfalls.
The observation of water quality samples and laboratory results of these sampling points are shown in (Table 6).

Table 4. Measured discharges of Euphrates River and drains outfalls within the study area during winter season

Stations	Coordinates		Discharge m^3/s	Date
	Easting, *m*	Northing, *m*		
Al Ya'uo Regulator	453736	3505121	16.0*	5/3/2012
Eastern Al Jarah Drain	454118	3505045	18.0	5/3/2012
Euphrates River after Eastern Al Jarah Drain	454180	3500358	34.0	5/3/2012
Euphrates River before Al-Khassf Drain	457640	3498610	35.0	5/3/2012
Al-Khassf Drain	458763	3496489	1.5*	6/3/2012
Euphrates River after Al-Khassf Drain	459112	3496412	36.5	6/3/2012
Euphrates River before AnNagara Drain	460216	3496869	38.5	6/3/2012
AnNagara Drain	460465	3497762	32.5*	6/3/2012
Euphrates River after AnNagara Drain	461390	3496550	71.0	6/3/2012
Euphrates River after Al-Haffar Drain	464277	3495384	72.5*	6/3/2012
Euphrates in AshShinnafiyah City	466690	3493687	66.5	6/3/2012
Euphrates D/S AshShinnafiyah City	465956	3491351	67.0*	7/3/2012
Euphrates between AshShinnafiyah and Garrb	473838	3484875	67.5*	7/3/2012
Euphrates River (AsSbeel River) in Garrb village	480372	3479757	69.0	7/3/2012
Euphrates River (AsSbeel River) D/S Garrb	487888	3482974	70.0*	7/3/2012
Euphrates in Al Bassamiya	499082	3478445	69.5*	7/3/2012
Euphrates U/S Al Hillal region	503222	3474623	60.0*	7/3/2012
Euphrates in Al Hillal region	510619	3476623	57.4*	7/3/2012
Euphrates in AsSewear region	519309	3473757	61.0*	8/3/2012
Aum-Al A'kaf Drain	520225	3470633	0.5*	8/3/2012
Euphrates before Al Atshan	520399	3470421	59.0	8/3/2012
Al-Atshan River	522493	3465420	2.0	8/3/2012
Euphrates after confluence	524268	3465777	61.0	8/3/2012
Euphrates River on AsSamawa City	527803	3464535	54.0	8/3/2012

- (*) *the added stations during winter seasons.*

Implementation of the Models using HEC-RAS Software:

The study area are extend for a reach length of 117 *km* from station 718 which is located 5 *km* southern Al-Ya'uo Regulator till station 835 at AsSamawa City.

Flow Data:

Steady flow data consists of: the number of profiles to be computed; the flow data; and the river system boundary conditions.

Table 5. Calculated Discharges of Euphrates River, intakes and drain outfalls within the study area during Winter Season

Name of Stations	Coordinates Easting m	Northing m	Discharge m^3/s
Gammas Outfall	457558	3499091	1.0
AnNagashiya outfall	460223	3496975	2.0
Al-Haffar Drain	463170	3496366	1.5
Water Intakes U/S AshShinnafiyah (Aal-Shibel)	-	-	-8.0
Group of outfalls and drains on Euphrates River D/S AshShinnafiyah City	-	-	0.5
Water Intakes D/S AshShinnafiyah City (Saied Hussein)	-	-	-2.0
Group of outfalls and drains on Euphrates River D/S AshShinnafiyah City	-	-	2.5
Water Intakes (Sultan AsSeqer)	-	-	-1.0
Group of outfalls and drains in Garrb village	-	-	2.5
Water Intake (Arab Mutlaq)	-	-	-0.5
Group of outfalls on Euphrates River D/S Garrb region	-	-	1.5
Water Intakes (Saied Hammed)	-	-	-1.5
Small Drain (Saied Hammed)	-	-	1.0
Water Intake (Al-A'lwaan)	-	-	-9.5
Water Intake U/S Al Hillal region	-	-	-4.0
Group of outfalls on Euphrates River in Al Hillal region	-	-	1.4
Group of outfalls (Al Majed)on Euphrates River	-	-	3.6
Water Intake in AsSewear region	-	-	-3.5
Water Intake before AsSamawa city	-	-	-7.0

Table 6. Coordinate, field and laboratory measurements of water quality sampling points during winter season.

Stations	Coordinates Easting, m	Northing m	EC, $\mu S/cm$	TDS, mg/l	Date
Al Ya'uo Regulator	453736	3505121	1490	1002*	5/3/2012
Eastern Al Jarah Drain	454118	3505045	4560	2965	5/3/2012
Euphrates River after Eastern Al Jarah	454180	3500358	3100	2030	5/3/2012
Euphrates River before Al Khassf Drain	457640	3498610	3400	2230	5/3/2012
Al-Khassf Drain	458763	3496489	3110	2095	6/3/2012
Euphrates River after Al Khassf Drain	459112	3496412	3300	2170*	6/3/2012
Euphrates River before AnNagara Drain	460216	3496869	3600	2310	6/3/2012
AnNagara Drain	460465	3497762	4550	2945	6/3/2012
Euphrates River after Al-Haffar Drain	464277	3495384	3980	2675*	6/3/2012
Euphrates in AshShinnafiyah City	466690	3493687	3890	2650	6/3/2012
Euphrates D/S AshShinnafiyah City	465956	3491351	3900	2660*	7/3/2012
Euphrates between AshShinnafiyah and Garrb	473838	3484875	3800	2615*	7/3/2012
Euphrates River (AsSbeel River) in Garrb village	480372	3479757	4120	2745	7/3/2012
Euphrates River (AsSbeel River) D/S Garrb	487888	3482974	4500	2930*	7/3/2012
Euphrates in Al Bassamiya	499082	3478445	4400	2915*	7/3/2012
Euphrates U/S Al Hillal region	503222	3474623	3990	2680*	7/3/2012
Euphrates in Al Hillal region	510619	3476623	4590	3045*	7/3/2012
Group of outfalls (Al Majed) on Euphrates River	519265	3473813	12290	8382*	8/3/2012
Euphrates in AsSewear region	519309	3473757	4750	3360*	8/3/2012
Aum-Al A'kaf Drain	520225	3470633	13670	9367*	8/3/2012
Euphrates before Al Atshan	520399	3470421	4825	3590	8/3/2012
Al-Atshan River	522493	3465420	9110	6300	8/3/2012
Euphrates after confluence	524268	3465777	4920	3625*	8/3/2012
Euphrates River on AsSamawa City	527803	3464535	4910	3620	8/3/2012

At least one flow must be entered for every reach within the system. Additionally, flow may be changed at any location within the river system. The upstream boundary condition is the discharge downstream Al Ya'uo plus the discharge of Eastern Al-Jarah drain while the downstream boundary condition is the rating curve at AsSamawa city , (Fig.8) by, National Center for Water Resources Management (NCWRM). The study flow input data showing the scheme of the river and all intakes and outfall drains within the study area, (Fig. 7).

Water Quality Model

Water quality model was performed after it was coupled with hydraulic model. Accordingly, different values of dispersion coefficient were computed using Fisher equation adopting by data from the hydraulic model where found that the ranged value between 25 to 500 m^2/s for both seasons. Finally the chosen value was verified with the stations along the river reach at the same time as shown in (Fig.9) and (Fig.10) where the results were satisfactory.

Results and Discussion

The major sources of high salinity in Euphrates River within the study area are the main drains which drained in the River directly. Divert the outfall of the any drain or more than one drain into main outfall drain is called scenario in the present study. Scenarios were suggested to improve the water quality represented by total dissolved salts and to maintain water level greater than 6 m.a.m.s.l in the river reach at AsSamawa city which its water level requirement by NCWRM, these scenarios have been adopted on several assumptions that the source of interflow which outfall into the river are the drains.

Objective of Scenarios:

The purpose of the scenarios is to:

1. Study the hydraulicalics and water quality impact of each drain on Euphrates River.
2. Find the most appropriate proposal which can be adopted by decision maker .
3. Find the minimum instream flow for each scenario.

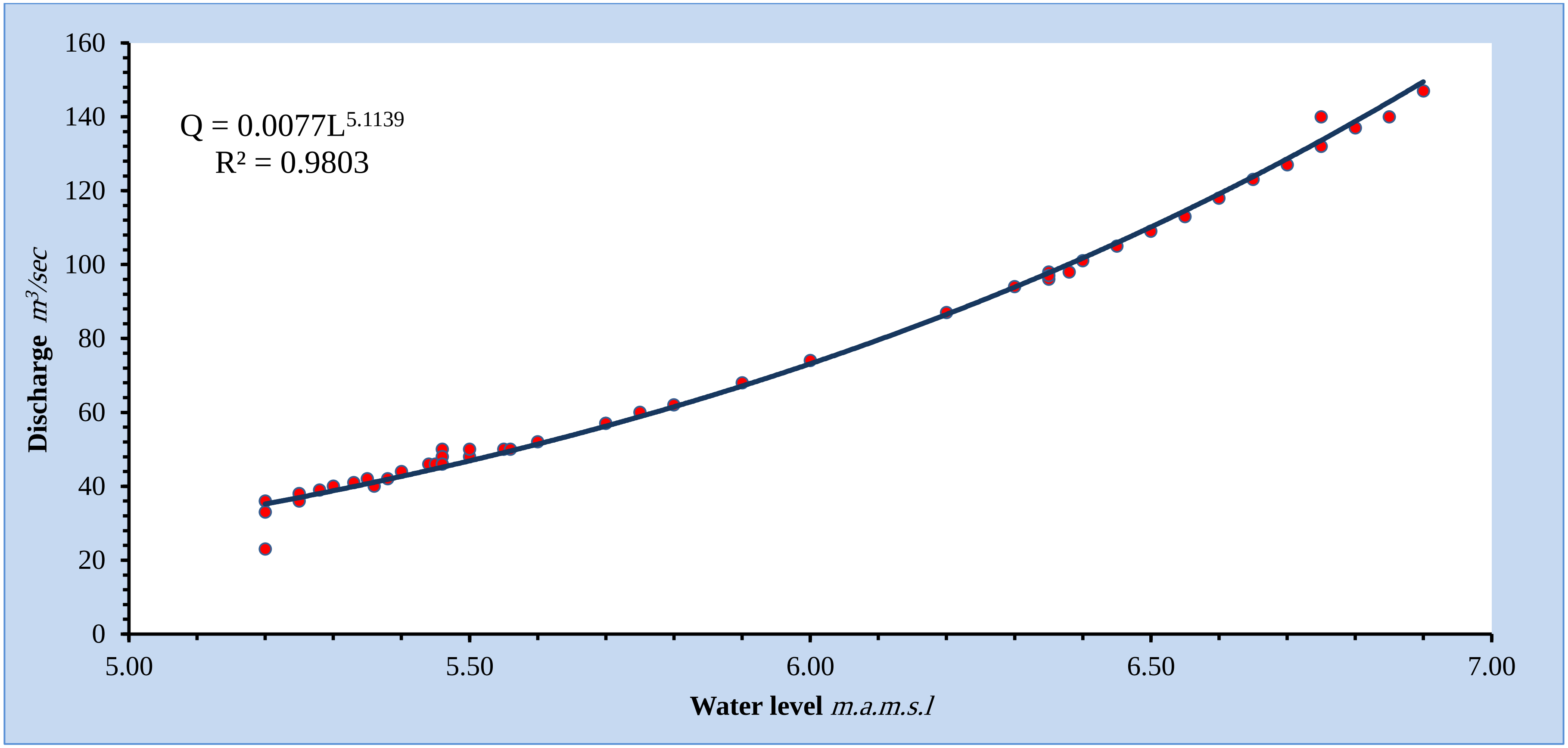

Fig.8. Rating curve at AsSamawa city station, National Center for Water Resources Management of the MoWR, 2010-2011.

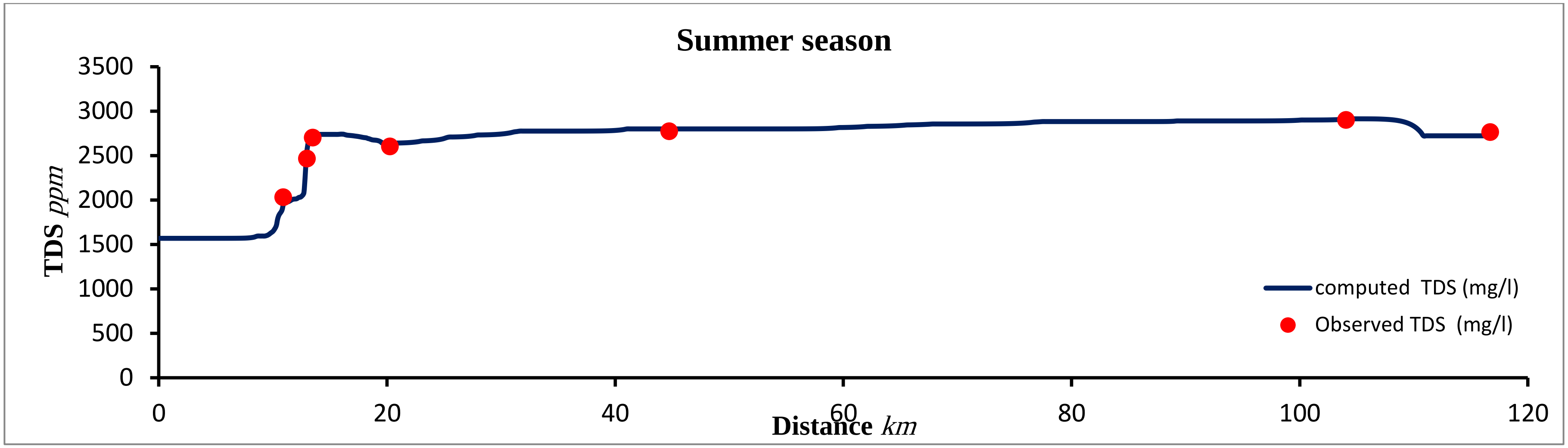

Fig. 9. Verification of water quality model within the study area during summer season.

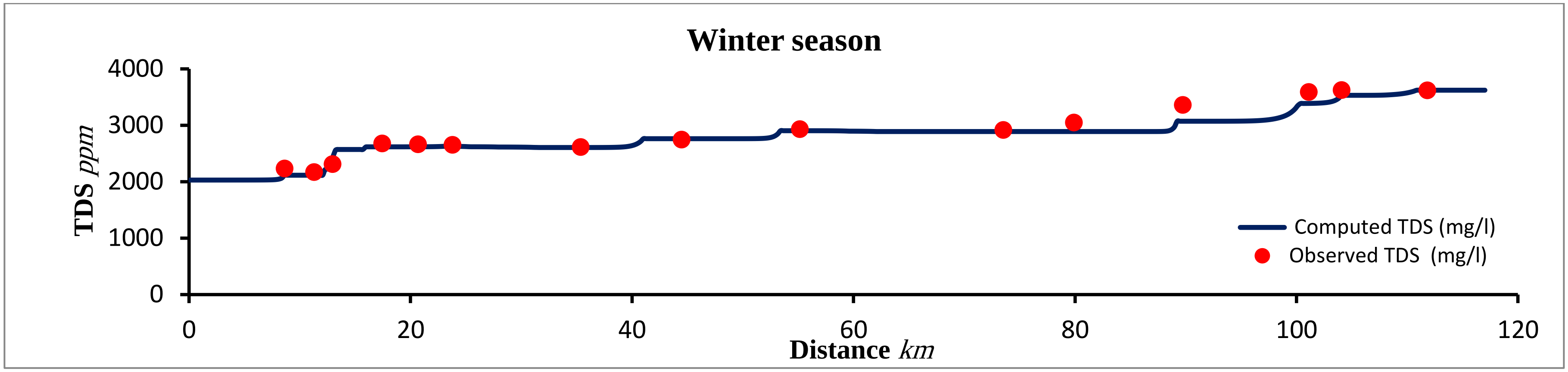

Fig.10. Verification of water quality model within the study area during winter season

DESCRIPTION OF SCENARIOS

After the preparation of the Mathematical Model and operation in accordance with the observed results, several scenarios been proposed intended to find the best scenario that can be applied to get the acceptable quality and quantity that represented by total dissolved solids along the river and minimum required water level at AsSamawa City, respectively,. Numbers of scenarios were prepared and described in (Table 6).

Table 6. Description of the adopted Scenarios within the steady area

Scenario Number	Description
1	Euphrates River With All Drains.
2	Euphrates River Without AnNagara Drain.
3	Euphrates River Without Al Khassf Drain.
4	Euphrates River Without Eastern Al Jarah Drain.
5	Euphrates River Without AnNagara and Eastern Al Jarah Drains.
6	Euphrates River Without Al Khassf and Eastern Al Jarah Drains.
7	Euphrates River Without AnNagara and Al Khassf Drains.
8	Euphrates River Without AnNagara, Al Khassf and Eastern Al-Jarah Drains.
9	Euphrates River Without Eastern Al Jarah Al Khassf, An Nagara, Al Haffar Drains, and outfalls Between AshShinnafiah and Garrb
10	Euphrates River Without All Drains.
11	Euphrates River Without Al Atshan River and All Drains.

PRESENT CONDITION AND THE SUGGESTED SCENARIOS:

The deterioration of water quality along the river in the study area is represented by amount of Total Dissolved Salts (TDS). The water is not suitable for agriculture use when it exceeds the allowable limit of 1500 *mg/l* according to the (Specification of Iraq No. 417 for maintenance of river pollution, 1967). The results of field and laboratory measurements during summer season showed that the low discharge downstream of Al-Ya'uo Regulator 17 m^3/s, in spite of the acceptable TDS 756 *mg/l* is very low discharge if it is compared with the main drains that outfall in Euphrates River. Few kilometers downstream Al Ya'uo regulator, TDS in the river was increased to be 1570 *mg/l* because the drainage water of Eastern Al Jarah drain that discharge its water into Euphrates River at kilometer 717.75 and is considered as one of the main factors of water quality deterioration of Euphrates River within the reach. TDS were continuously increased along the river reach till AsSamawa city which became 2762 *mg/l*, with discharge of 123 m^3/s and water level of 6.63 *m.a.m.s.l*, because of existing drains outfalls in the river directly. (Fig.11) shows that the variation of TDS along Euphrates River within the study area.

In winter season, it was found that TDS of Euphrates River at Al-Ya'uo Regulator was 1002 *mg/l* with a discharge of 16m^3/s and increased to reach 3620 *mg/l* with water level of 5.70 *m.a.m.s.l.* at AsSamawa city. The water level within the river at the AsSamawa city is lower than that in summer season and is below the required water level for irrigation purposes. The investigation for interflow effect in winter season is serious, because of precipitation and the river low water levels. Effect of interflow on Euphrates River water quality within the reach under consideration, southern AshShinnafiyah Town, is clear and shown in (Fig.12).

In other words, the drainage water and the deficit in fresh incoming water are the main factors of water quality deteriorations in Euphrates River within the study area. To control the water quality in Euphrates River, different scenarios, Table 6, were adopted to ensure as possible as acceptable limits for water quality and water levels along Euphrates River from downstream Al Ya'uo regulator till AsSamawa city.

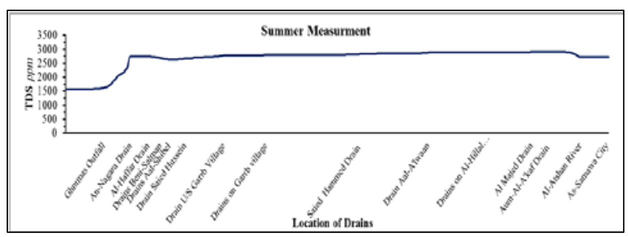

Fig.11. Salinity of water along the reach within the study area ,Summer season.

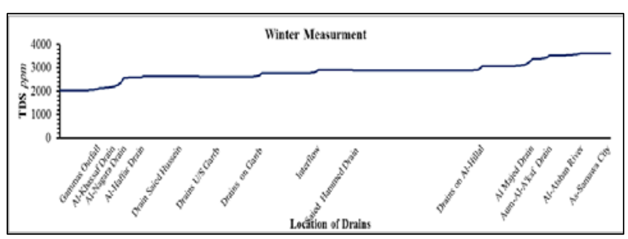

Fig. 12. Salinity of water along the reach within the study area, winter season.

Scenario 1 represents the actual river system with different supplied discharges through Al-Ya'uo regulator to find the required MIF that satisfy the TDS and the water level at AsSamawa city within the acceptable limits, showed that the TDS in the summer and winter seasons was higher than the acceptable limits if the discharge at of Al-Ya'uo regulator operated with its design value of 200 m^3/s. The required MIF were 287 m^3/s and 365 m^3/s for summer and winter season, respectively, as shown in (Fig.13) and (Fig.14).

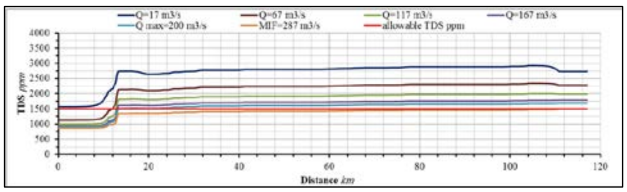

Fig.13. Salinity of water along the reach in Scenario 1, summer season

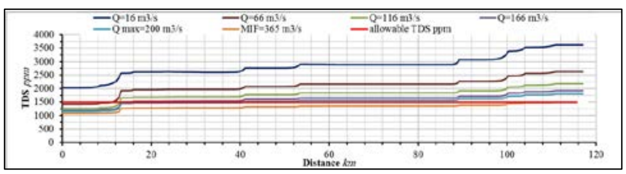

Fig.14. Salinity of water along the reach in Scenario 1, winter season.

(Fig.15) and (Fig.16) show that the variation in water levels along Euphrates River in the scenario. It must be noticed that the discharge of 25m^3/s during winter is required to get water level of 6 *m.a.m.s.l.* at AsSamawa city as minimum acceptable water level. From this scenario, it is clear that the deterioration in Euphrates River within the study area may be avoided only by diverting one or more of the drains that outfall in Euphrates River within the study area. In other words, it is impossible to improve the water quality in Euphrates River within the study area without diverting one or more of the drains that caused the deterioration.

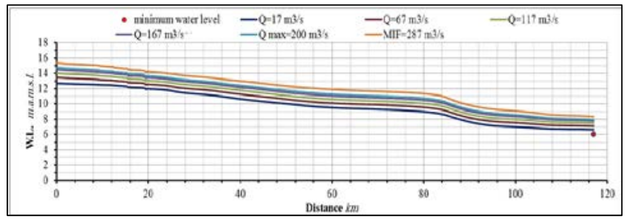

Fig.15. Water level along the reach in Scenario 1, summer season.

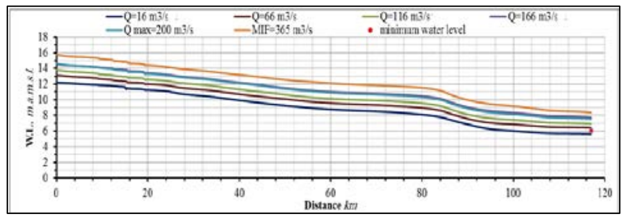

Fig.16. Water level along the reach in Scenario 1, winter season.

Moreover, when AnNagara drain is canceled, scenario 2, the results of the models showed that the values of MIF for summer and winter seasons are 135 m^3/s and 273 m^3/s respectively, (Fig.17) and (Fig.18). This scenario is active for summer season only with TDS at Al Ya'uo Regulator is 756 *mg/l*, but it's not active when TDS is greater than 1000 *mg/l*. Since the required MIF is higher than that the design discharge of Al-Ya'uo regulator for winter season, therefore the MIF is not possible when TDS is greater than 808 *mg/l*.
But, the computed water level at AsSamawa city for summer season is accepted with the above MIF as shown in (Fig.19). As well as in winter season, water levels with discharge of 66m^3/s will reach the acceptable value as shown in (Fig.20).

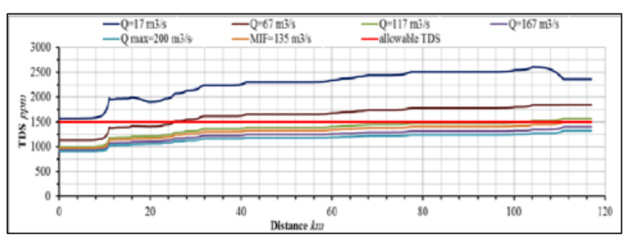

Fig.17. Salinity of water along the reach in Scenario 2, summer season.

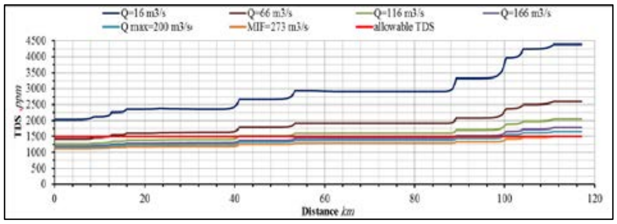

Fig.18. Salinity of water along the reach in Scenario 2, winter season.

Accordingly, the water quality and hydrological issue may be ensured during summer and the hydrological issue only during winter.

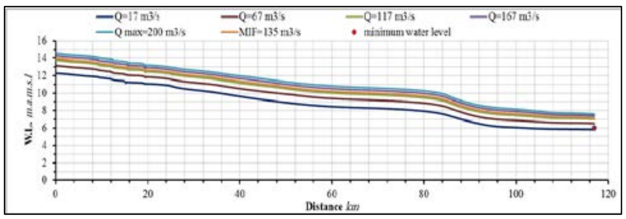

Fig.19. Water level along the reach in Scenario 2, summer season.

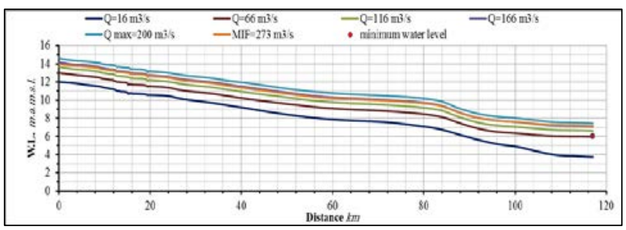

Fig.20. Water level along the reach in Scenario 2, winter season.

In scenario 3, Al Khassf drain was removed from the river system. The obtained results in this scenario showed that the required MIF exceed Al-Ya'uo Regulator design discharge during summer and winter as shown in (Fig.21) and (Fig.22). The problem of water quality in Euphrates River will not be solved during the summer season 2011 when the TDS in Al Ya'uo Regulator is greater than 585 *mg/l* with the maximum design discharge, but in winter season 2012 the water quality will not be improved when the TDS in Al Ya'uo Regulator is greater than 560 *mg/l* with the maximum design discharge.

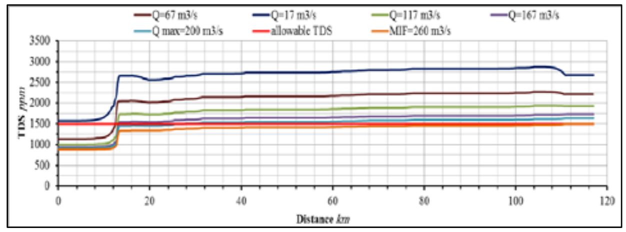

Fig.21. Salinity of water along the reach in Scenario 3, summer season.

Moreover, the water level along this river reach is above the minimum required water level in summer, (Fig.23),

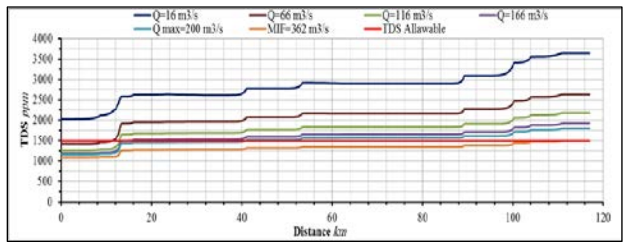

Fig.22. Salinity of water along the reach in Scenario 3, winter season.

but the discharge 37 m3/s is required during winter to satisfy that minimum water level as shown in (Fig.24).

The problem of water quality in Euphrates River will not be solved during the summer season 2011 when the TDS in Al Ya'uo Regulator is greater than 585 *mg/l* with the maximum design discharge, but in winter season 2012 the water quality will not be improved when the TDS in Al Ya'uo Regulator is greater than 560 *mg/l* with the maximum design discharge.

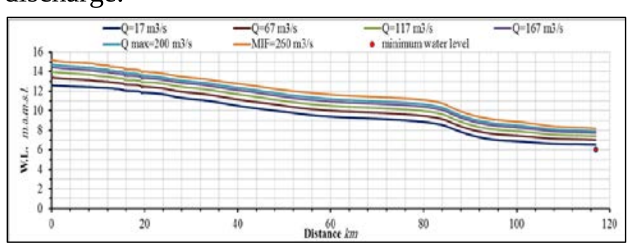

Fig.23. Water level along the reach in Scenario 3, summer season.

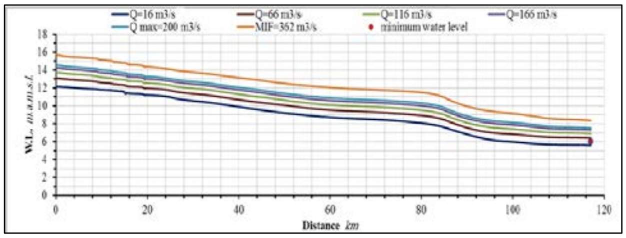

Fig.24. Water level along the reach in Scenario 3, winter season.

Another alternative was prepared where the Eastern Al Jarah drain was canceled from the river system and named as scenario 4. The obtained results in this scenario showed that the required MIF exceed Al-Ya'uo Regulator design discharge during summer and winter seasons as shown in (Fig.25) and (Fig.26).

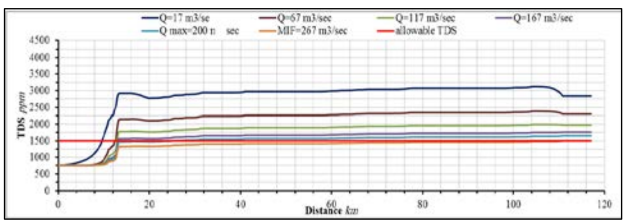

Fig.25. Salinity of water along the reach in Scenario 4, summer season.

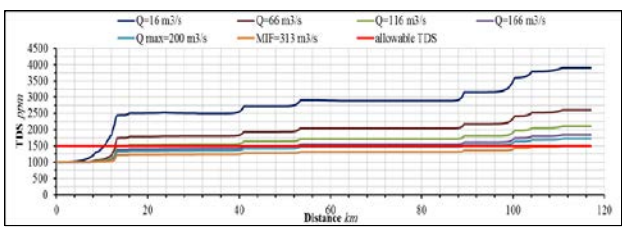

Fig.26. Salinity of water along the reach in Scenario 4, winter season.

But the water level along this river reach is above the minimum required water level in summer season with existing discharge, (Fig.27), and the discharge 53 m^3/s is required during winter to satisfy that minimum water level as shown in (Fig.28). Additionally, the deterioration in Euphrates River in summer and winter season cannot be avoided when TDS downstream Al Ya'uo Regulator is higher than 518 *mg/l* and 706 *mg/l* respectively.

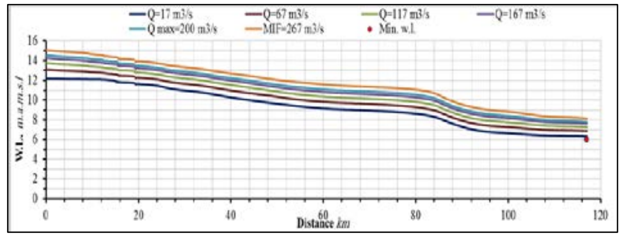

Fig.27. Water level along the reach in Scenario 4, summer season.

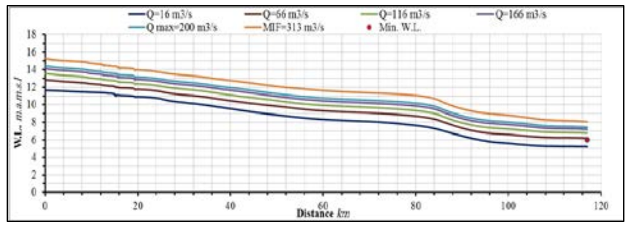

Fig.28. Water level along the reach in Scenario 4, winter season.

When Eastern Al Jarah and AnNagara drains are removed, scenario 5, the results of the models showed that the value of MIF for summer and winter seasons are 117 m^3/s and 225 m^3/s respectively, (Fig.29) and (Fig.30). This scenario is active for summer season only with TDS at Al Ya'uo Regulator is 756 *mg/l*, but it's not active when TDS is greater than 1076 *mg/l*. No possible MIF when TDS Downstream Al-Ya'uo is greater than 938 *mg/l* during winter season.

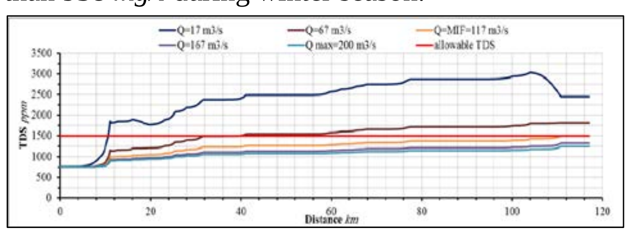

Fig.29. Salinity of water along the reach in Scenario 5, summer season.

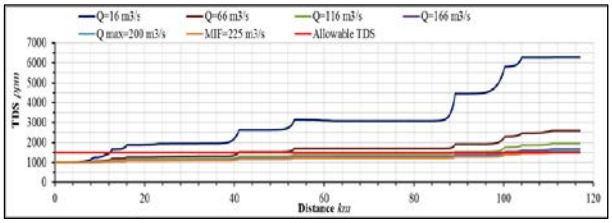

Fig.30. Salinity of water along the reach in Scenario 5, winter season.

Moreover, the computed water level at AsSamawa city for summer season is accepted with discharge greater than, 53 m^3/s as shown in (Fig.31). As well as in winter season, water levels with discharge greater than, 86 m^3/s will reach the acceptable value as shown in (Fig.32). Accordingly, the water quality and hydrological issue may be ensured during summer and the hydrological issue only during winter.

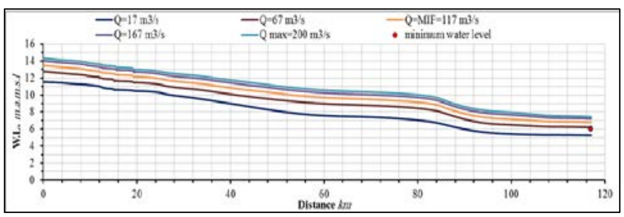

Fig.31. Water level along the reach in Scenario 5, summer season.

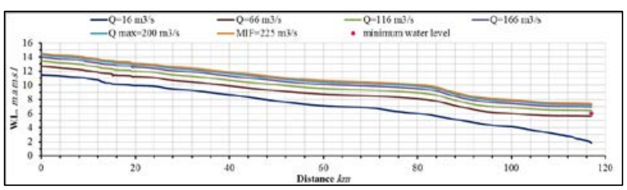

Fig.32. Water level along the reach in Scenario 5, winter season.

Also, when Eastern Al-Jarah and Al-Khassf drains were removed from river system, scenario 6, it was found that the value of MIF for summer and winter seasons are 240 m^3/s and 312 m^3/s respectively, (Fig.33) and (Fig.34). So, it is inapplicable scenario. Additionally, the deterioration in Euphrates River cannot be avoided in this scenario during summer and winter seasons when the TDS in Al Ya'uo Regulator is greater than 659 *mg/l* and 710 *mg/l* respectively.

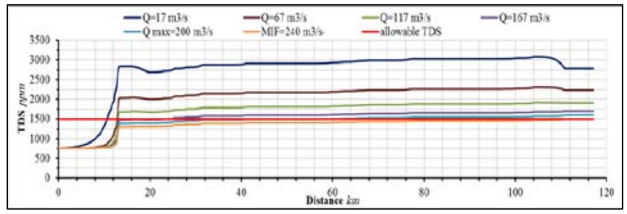

Fig.33. Salinity of water along the reach in Scenario 6, summer season.

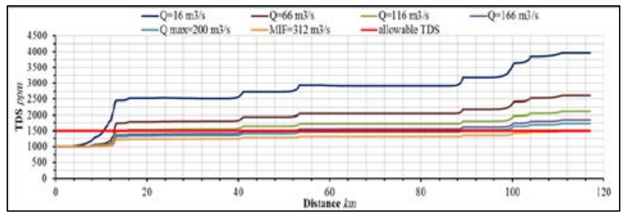

Fig.34. Salinity of water along the reach in Scenario 6, winter season.

Therefore, when the water level is computed at AsSamawa city for summer season is above the minimum required water level in summer season as shown in (Fig.35). As well as in winter season, water levels when the discharge is greater than of 55 m^3/s will reach the acceptable value as shown in (Fig.36).

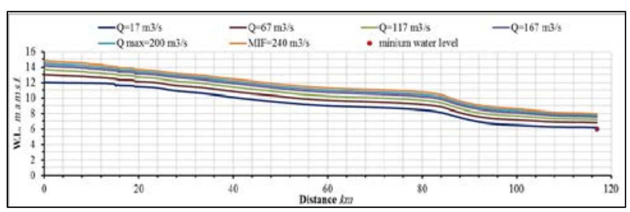

Fig.35. Water level along the reach in Scenario 6, summer season.

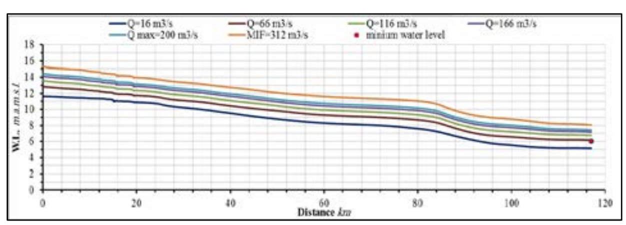

Fig.36. Water level along the reach in Scenario 6, winter season.

When Al-Khassf and AnNagara drains were canceled from river system, scenario 7, the results of the models showed that the value of MIF for summer and winter seasons are 110 m^3/s and 272 m^3/s respectively, (Fig.37) and (Fig.38). This scenario is active for summer season only with TDS at Al Ya'uo Regulator is 756 *mg/l*, but it's not active when TDS is greater than 1100 *mg/l*, while the MIF is not possible for winter season when TDS is greater than 810 *mg/l*.

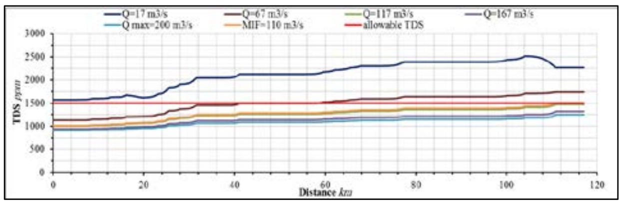

Fig.37. Salinity of water along the reach in Scenario 7, summer season.

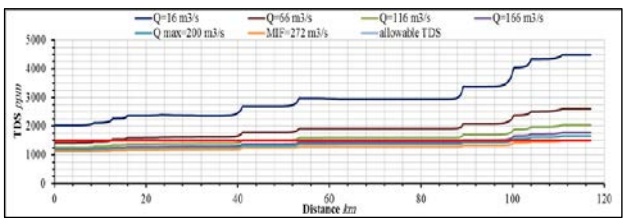

Fig.38. Salinity of water along the reach in Scenario 7, winter season.

Moreover, the computed water level at AsSamawa city for summer and winter seasons are accepted when the discharges at Al Ya'uo are greater than 27 m^3/s and 65 m^3/s, respectively, (Fig.39) and (Fig.40).

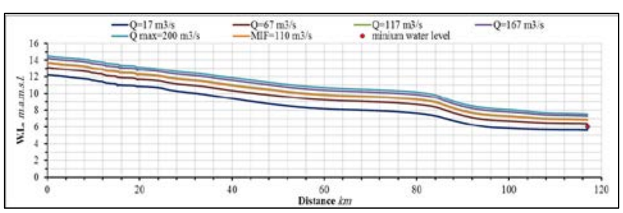

Fig.39. Water level along the reach in Scenario 7, summer season.

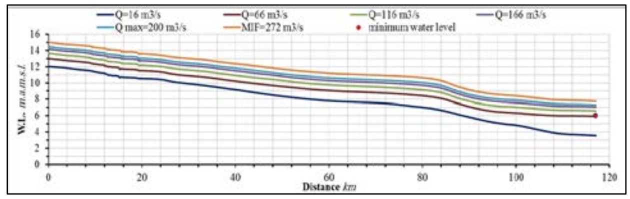

Fig.40. Water level along the reach in Scenario 7, winter season.

However, when Eastern Al Jarah, Al Khassf and AnNagara drains were terminates from river system which named as scenario 8, the obtained results show that the value of MIF for summer and winter seasons are 94 m^3/s and 224 m^3/s respectively, (Fig.41) and (Fig.42). This scenario is active for summer season only with TDS at Al Ya'uo Regulator is 756 *mg/l*, but it's not active when TDS greater than 1176 *mg/l*. For winter season, the MIF is not possible when the TDS at Al Ya'uo Regulator is greater than 938 *mg/l*.

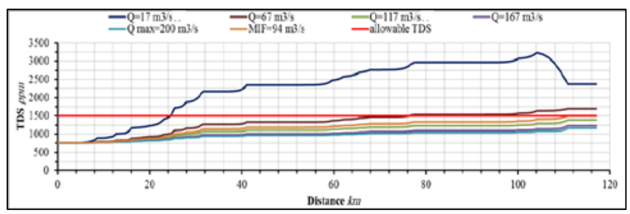

Fig.41. Salinity of water along the reach in Scenario 8, summer season.

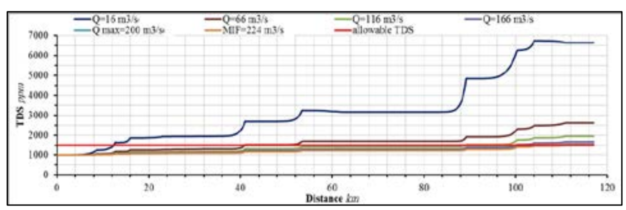

Fig.42. Salinity of water along the reach in Scenario 8, winter season.

Water level at AsSamawa city in summer and winter seasons are accepted with discharges of 67m3/s and 87m3/s respectively, (Fig.43) and (Fig.44).

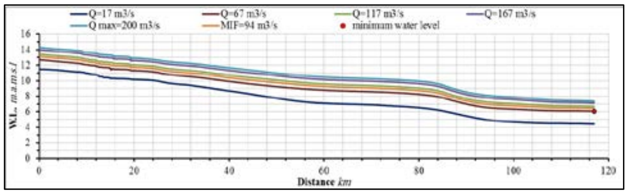

Fig.43. Water level along the reach in Scenario 8, summer season.

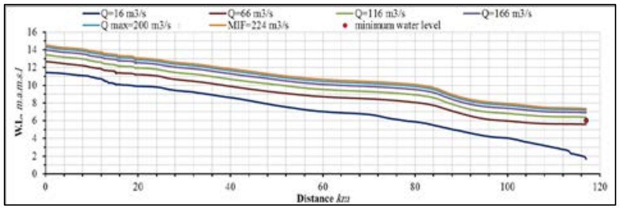

Fig.44. Water level along the reach in Scenario 8, winter season.

Since the above scenarios are inapplicable during winter season, additional scenarios were adopted to find the scenario that satisfies the required water quality and hydrological issues over the year. Scenario 9 was achieved by eliminate Eastern Al-Jarah, Al-Khassf , AnNagara and Al-Haffar drains and all outfalls drains between AshShinnafiyah Town and Garrb Village. It was found form the hydraulic model that the river will be dry if the discharges are 17 and 16 m^3/s in summer and winter seasons, respectively because there are several intakes that will deplete the river. So, the river discharges must be compensating by about 50 m^3/s from Al Ya'uo regulator during both seasons to overcome this problem. The results of the models showed that there were no problems in TDS during summer season with discharge 63 m^3/s see (Fig.45), while the required MIF is 165 m^3/s during winter season, (Fig.46).

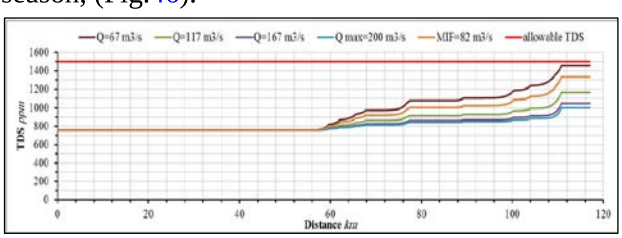

Fig.45. Salinity of water along the reach in Scenario 9, summer season.

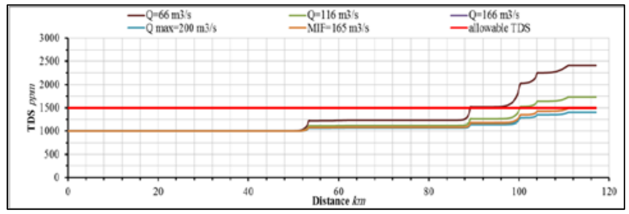

Fig.46. Salinity of water along the reach in Scenario 9, winter season.

From Hydraulic parts, the summer season needs discharge 82 m^3/s from Al-Ya'uo Regulator, to achieve the minimum water level in AsSamawa city as shown in (Fig.47). In winter season, the discharge is 97 m^3/s needs to achieve the minimum water level in AsSamawa city as shown in (Fig.48).

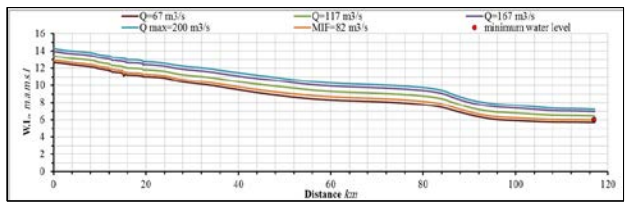

Fig.47. Water level along the reach in Scenario 9, summer season.

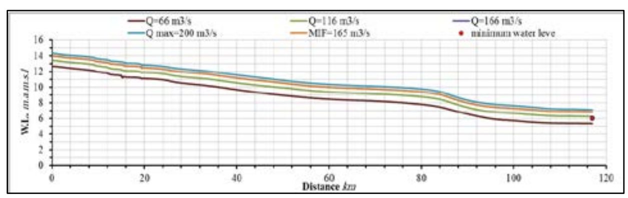

Fig.48. Water level along the reach in Scenario 9, winter season.

This scenario may be considered as the best scenario comparing with the above mentioned scenarios, but may be costly. Additional scenario that represents the river reach without any drain outfall is named as scenario 10. As in the above scenario the minimum discharges that ensure the flow in the river during summer and winter are 40 and 48 m^3/s. The results of the models showed that TDS is within the acceptable limits along the reach during summer and winter seasons, as shown in (Fig.49) and (Fig.50).

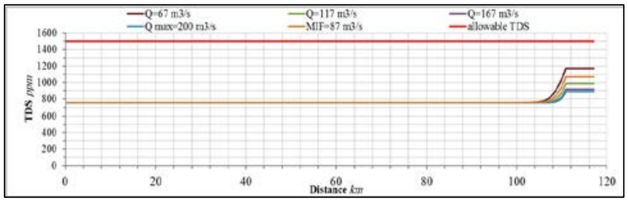

Fig.49. Salinity of water along the reach in scenario10, summer season.

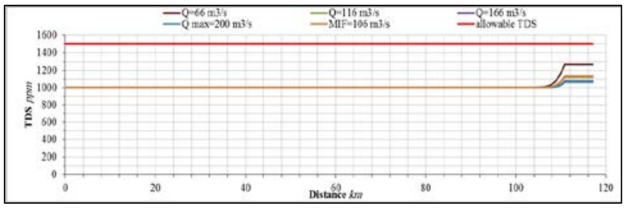

Fig.50. Salinity of water along the reach in scenario 10, winter season.

The required MIF's to satisfy the hydraulic requirements for summer and winter seasons are 87 m^3/s and 106 m^3/s, respectively as shown in (Fig.51) and (Fig.52).

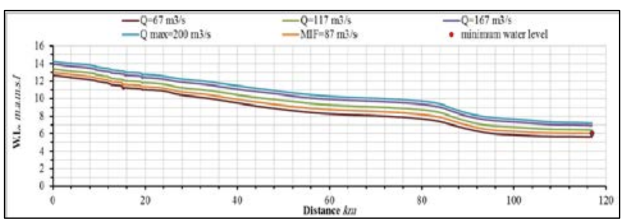

Fig.51. Water level along the reach in scenario 10, summer season.

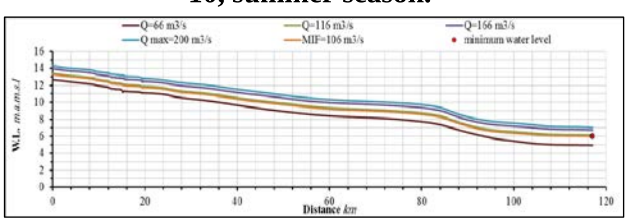

Fig.52. Water level along the reach in scenario 10, winter season.

Finally, as in scenario 10 with termination of Al-Atshan River is mentioned as scenario11 .The main results of the water quality part are presented in (Fig.53) and (Fig.54). It is clear there is no problem in TDS value.

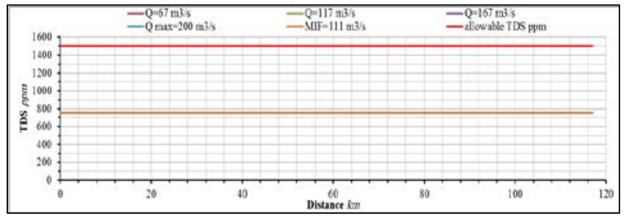

Fig.53. Salinity of water along the reach in scenario11, summer season.

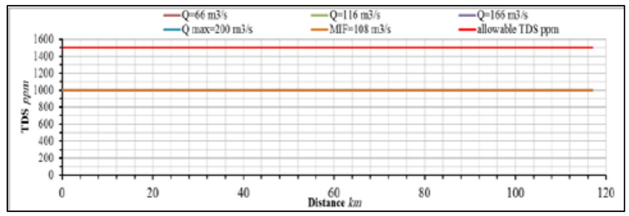

Fig.54. Salinity of water along the reach in scenario11, winter season.

But, the MIF values that satisfy hydraulic requirement during summer and winter seasons are 111 m^3/s and 108 m^3/s see (Fig.55) and (Fig.56).

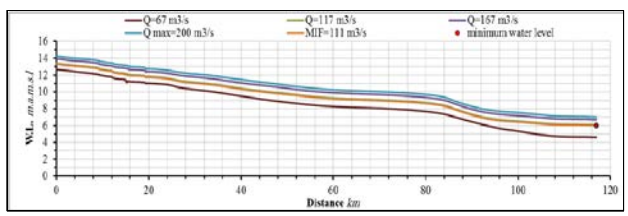

Fig.55. Water level along the reach in scenario 11, summer season.

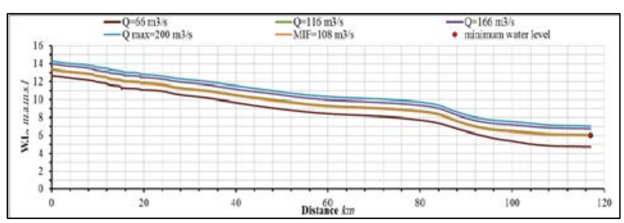

Fig.56. Water level along the reach in scenario 11, winter season.

The above scenarios are summarized in (Table 7) according to the possibility of the hydraulic and water quality requirements and to give the decision maker more than one alternative.

The last three scenarios are more sufficient than the first-eight scenarios and the required MIF during any season is based on the recorded data of TDS at Al Ya'uo regulator from the presented charts in each scenario.

Table 7. MIF values and possibility of each adopted scenario for water quality and hydrological requirements.

Scenario Number	MIF, m^3/s				Satisfy the acceptable limit			
	TDS , 1500 mg/l		Water level , 6 $m.a.m.s.l.$		Water Quality		Water Level	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1	287	365	-	25	Impossible	Impossible	possible	possible
2	135	273	27	66	possible	Impossible	possible	possible
3	260	362	-	37	Impossible	Impossible	possible	possible
4	267	313	-	53	Impossible	Impossible	possible	possible
5	117	225	53	86	possible	Impossible	possible	possible
6	240	312	3	55	Impossible	Impossible	possible	possible
7	110	272	27	65	possible	Impossible	possible	possible
8	94	224	67	87	possible	Impossible	possible	possible
9	**63**	**165**	**82**	**97**	**possible**	**possible**	**possible**	**possible**
10	**40**	**48**	**87**	**106**	**possible**	**possible**	**possible**	**possible**
11	-	-	**111**	**108**	**possible**	**possible**	**possible**	**possible**

CONCLUSIONS:

Absence of hydrological and water quality represented by salinity of water stations along Euphrates river within the study area leads to use the only available data at AshShinnafiyah and AsSamawa stations. These two stations were used to check the measured data that accomplished through 12 main hydrological stations and 15 stations of water quality that selected along the river reach during summer (7-2011) and 23 hydrological and water quality stations during winter (3-2012).

This paper deduced the following conclusions:

1. The most important reason for the increasing salinity of Euphrates River in study area is the irrigation return-flow represented by the drains, which outfalls on the river directly, especially that are located upstream Garrb village.
2. The salinity increasing of Euphrates River in winter season is greater than that of summer season, because of low discharge at Al Ya'uo regulator; higher drains water salinity "TDS" that were outfalls in the river and the effect of interflow.
3. Scenarios 1, 3, 4 and 6 that represents the actual river system with different supplied discharges through Al-Ya'uo regulator, Al-Khassf drain was canceled from the river system, the Eastern Al Jarah drain was canceled from the river system, and when Eastern Al-Jarah and Al-Khassf drains were removed from river system respectively, are not applicable during (Jul.2011) and (Mar. 2012).
4. Scenarios 2, 5, 7 and 8 that represents the river system without AnNagara drain, the river system without Eastern Al Jarah and AnNagara drains, the river system without Al Khassf and AnNagara drains, and the river system without Eastern Al Jarah, Al Khassf and AnNagara drains respectively, are possible during summer (Jul.2011) and impossible during winter (Mar. 2012).
5. Scenarios 9, 10 and 11, that represents the river system without Eastern Al-Jarah, Al-Khassf , AnNagara and Al-Haffar drains and all outfalls drains between AshShinnafiyah Town and Garrb Village, the river system without all drains, and the river system without all drains and Al-Atshan River respectively, are applicable scenarios with different required MIF during the two measured seasons.
6. Scenario 9 is the best scenario that may apply to the study area with minimum cost and MIF comparing with scenarios 10 and 11.

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