Feb. 2013, Volume 7, No. 2 (Serial No. 63), pp. 238-247
Journal of Civil Engineering and Architecture, ISSN 1934-7359, USA

Study of the Effects of Water Level Depression in Euphrates River on the Water Quality

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Abstract: The Tigris and Euphrates Rivers are the main sources of water in Iraq. Iraq used to receive 33 × 109 m^3 of river water per year at Hit, 200 km downstream from the Syrian border before the 1970s. In 1980s, the discharge decreased to as little as 8×10^9 m^3 per year at Hit. The decreasing of discharge and water level in the Euphrates River causes problems of both quantity and quality, such as the increasing salinity in the internal delta downstream, the TDS (total dissolves salinity) at Hit has increased from less than 500 ppm to about 700 ppm. By 1989, the Euphrates' salinity at Al Qaim reached 1,000 ppm. Currently, the TDS of the river, at Al Qaim, is greater than 1,000 ppm. The problem of control salinity has received considerable attention particularly when the surface water is extremely limited with poorly available ground water supply. The field measurement has achieved for TDS, pH (hydrogen ion), EC (electric conductivity), coliform content and heavy metal for three sectors in the Euphrates River basin in Iraq as well as the lakes of Tharthar, Habbaniya, and Al-Razzaza. The statistical analysis was made to relate these parameter with discharge and water level, which are refered to the important effect of the flow in river on the water quality of Euphrates River. The storage of water in the lakes Al-tharthar, Al-habbanya, and Al-Razzaza has a negative effects on the water quality, and shows that the best method for storage water is the reservoirs along river stream.

Key words: Euphrates River, water quality, water level depression.

1. Introduction

Tigris and the Euphrates Rivers (Fig. 1) suffer from discharge decreasing greatly within the last few years and water quality deteriorate because the problems of high levels of salinity. The decreasing of discharge and water level in the Euphrates River causes problems of both quantity and quality, such as the increasing salinity in the internal delta downstream, for example, the TDS at Hit had increased from less than 500 ppm to about 700 ppm. Iraq used to receive 33 × 109 m^3 of river water per year at Hit, 200 km downstream from the Syrian border before the 1970s, when both Turkey and Syria built a series of large dams on the Euphrates River (Fig. 2). By the end of the 1980s, the discharge decreased to as little as 8 × 109 m^3 per year at Hit (Fig. 3). By 1989, the Euphrates' salinity at Al Qaim reached 1,000 ppm.

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The Euphrates River has its springs in the highlands of Eastern Turkey and its mouth at the Arabian Gulf. It is the longest river in southwestern Asia with 2,700 km. The Euphrates River is formed in Turkey by two major tributaries, the Murat and the Karasu. These two streams join together around the city of Elazig, and the Euphrates River follows a southeastern route to enter Syria at Karakamis point. After entering Syria, the Euphrates continues its southeastern course and is joined by two more tributaries, the Khabur and the Balikh. Both of these tributaries have their sources in Turkey and they are the last bodies of water that contribute to the river. After entering Iraq, the river reaches the city of Hit, where it is only 53 m above sea level. From Hit to the delta in the Arabian Gulf, for 735 km, the river loses a major portion of its waters to irrigation canals and to Hammar Lake. The remainder joins the Tigris River near the city of Qurna, and the combined rivers are called the Shatt al-Arab. The Karun River from Iran joins the Shatt at Basra,

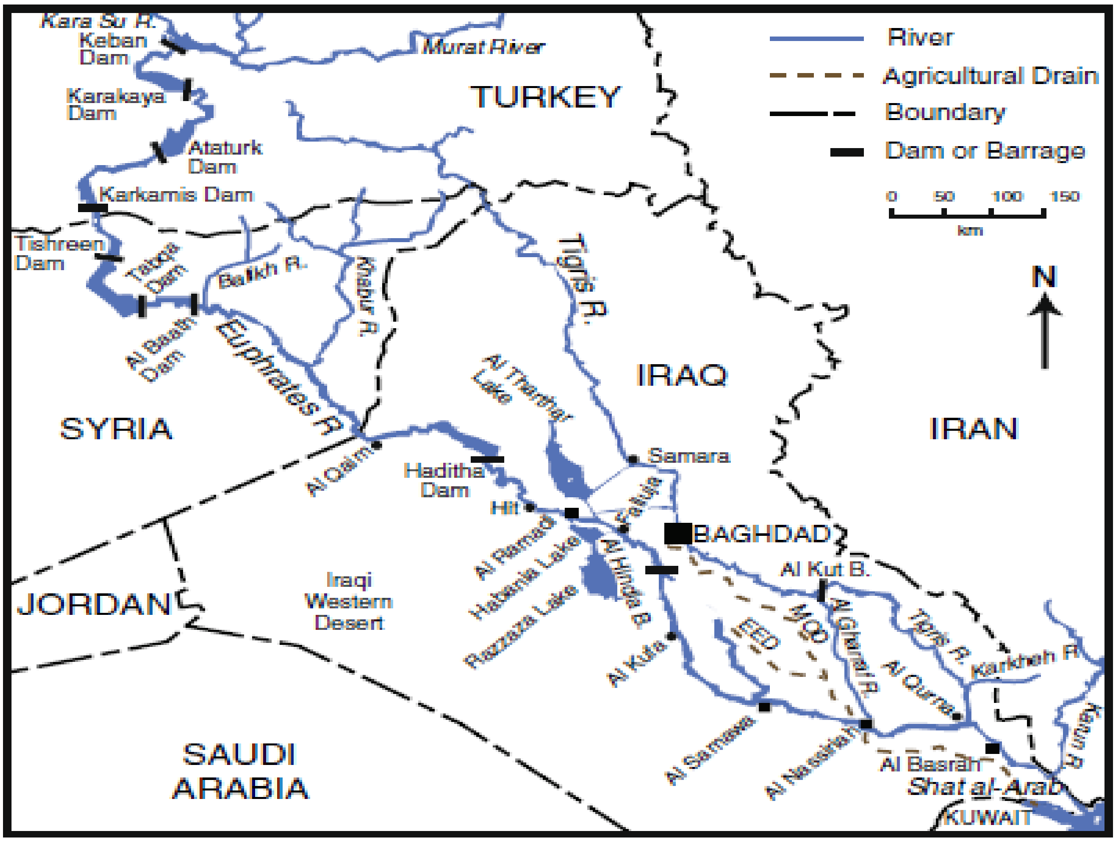

Fig. 1 Tigris and Euphrates basin with major dams in Turkey and Syriya (National Center for Water Resources Management, Iraq).

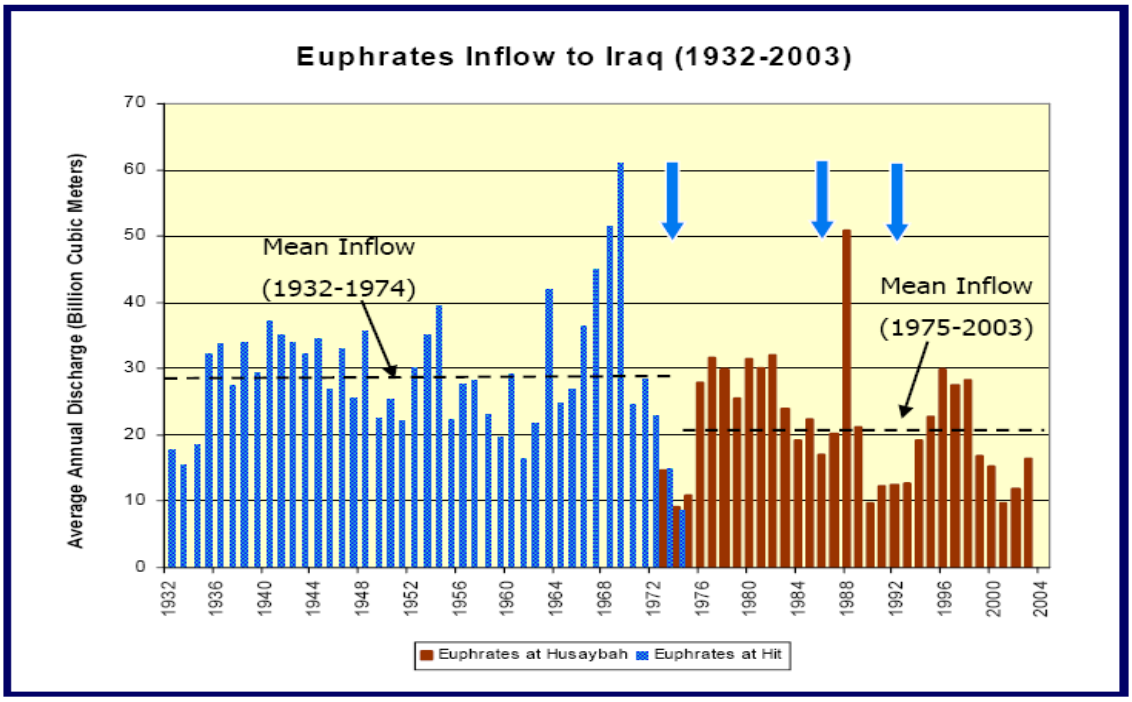

Fig. 2 Inflow of Euphrates River in Iraq [1].

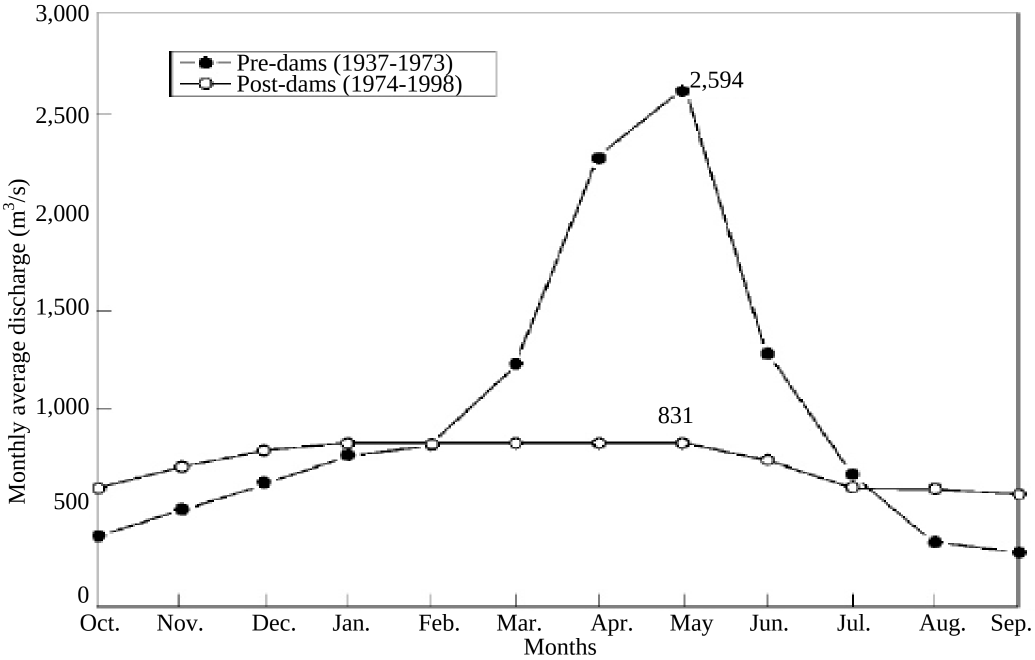

Fig. 3 Monthly discharge in the Euphrates River at Hit (1937-1998), pre, and post dams built [1].

and they empty into the Arabian Gulf altogether.

Hydrological study was initiated in 1927-1929 by installing the first pluviometric stations in the basin of the Firat, the uppermost part of the Euphrates. Long-term records indicate an average annual precipitation of about 625 mm in the Keban Basin, decreasing to approximately 415 mm in the lower Firat Basin.

The upper part of the Euphrates Basin has a catchments area of 63,874 km^2 at the confluence of the Firat and the Murat near the Keban, which produces 80% of the total annual flow at Karababa/Ataturk. The average flow at Keban station over the 31 years of records (1936-1967) was 648 m^3/sec, with the lowest flow of 136 m^3/sec in September 1961 and the maximum flood of 6,600 m^3/sec in May 1944. The long-term annual average discharge at the Karababa/Ataturk dam site is estimated to be 830 m^3/sec.

Before Turkey began building large dams on the Euphrates, the river's average annual flow at the Turkish-Syrian border was about 30×10^9 m^3. To this, a further 1.8×10^9 m^3 is added in Syria from the Khabour River, a major tributary. On several occasions in recent years, low water levels in the Lake Assad reservoir, behind the Tabqa Dam, have restricted the hydro-power output (with installed capacity of 800 MW) and irrigation development. In the longer term, a reduction in Euphrates water entering the country could be a major constraint on Syrian power generation and agriculture. By 1989, 80% of the natural run-off of the Euphrates River had been developed by adding a third large dam, the Ataturk, which is the largest dam in Turkey, with a gross reservoir storage volume of 48.7×10^9 m^3 (effective volume, 19.3×10^9 m^3).

The development of the Euphrates, which has problems of both quantity and quality, such as the increasing salinity in the internal delta downstream, is examined to distinguish the complexities, commonalities, and conflicts over riparian issues which put the peace of the world at risk.

The total flow of the Euphrates is not as great as that of the Tigris, although the river regimes are similar. It also rises in the highlands of Turkey and is fed by melting snows, to an even greater extent than the Tigris, but it lacks the major tributaries which the Tigris has. In Iraq, the period of maximum flow on the

Euphrates is shorter and later than that of the Tigris and is usually confined to the months of April and May. Discharge during the two months accounts for 42% of the annual total. Minimum flows occur from August through October and contribute only 8.5% of the total discharge. The mean annual runoff of the Euphrates is 35.2×10^9 m^3 at its confluence with the Tigris [2, 3].

These mean values, however, conceal the fluctuations in discharge that can occur from year to year, for it must be remembered that both floods and drought are themselves of variable magnitude.

2. Euphrates River Development and Salinity Problems

Historically, the Euphrates waters had low salinity. At the Keban gauging station, Turkey, the TDS was 261 ppm. 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, the TDS was 467 ppm in 1970 [4]. The TDS at Al Samawa was about 525 ppm for the year of 1955. The available spatial salinity data shows that salinity did not exceed 1,000 ppm throughout the course of the river in Iraq as of 1973. The pre-1973 data were averaged from Al-Hadithi 1978, and the post-1980 from the Ministry of Irrigation 1998. Ali and Salewicz 2005 published a salinity profile along the river from Al Qaim to Al Nassiriah for the water year 2000-2001 [5]. The profile shows salinity of about 1,000 ppm in Al Qaim, 1,100 ppm in Al Hindia, 3,000 ppm in Al Samawa, and 4,000 ppm in Al Nassiriah. 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 [6].

In present study, salinity data for the Euphrates' waters were analyzed to reveal the temporal and spatial salinity variations along the Euphrates in Iraq. Available data for stations along the river from its entrance, at Al Qaim, to the south station of Al Hindya were separated into two groups, the first represents the river discharge and salinity status before building large dam in Turkey and Syria which is designated "prior to 1990 when Ataturk dam was complete and operate", and the second group represents the river discharge and salinity for the period from 1990 to the present.

The available salinity records at the Al Fallujah monitoring station for the period before 1990 were studied to provide a baseline for comparison with later data. This station was chosen for analysis because its location represents a transition region between desert region of Euphrates River basin in the west and sedimentary lowland of the basin in the south. The influence of the return irrigation inflow on the river reach from drainage channel and inflow from Al-Tharthar reservoir was evaluated using the salinity data available. Available salinity measurements at the stations of Hussaiba, Ramadi, Fallujah, and Hindya were plotted against time for the several periods to evaluate the temporal salinity and its relation with discharge along the river (Figs. 4-9).

The river's salinity has increased over the last three decades with oscillated mean. The first noticeable as seen in Fig. 4 increase in salinity was recorded at the Hussaiba station in two periods, in 1990 when the filling of the upstream reservoirs (Ataturk dam) began and in 2000 when the minimum discharge was recorded. Fig. 4 shows that the TDS at Hussaiba had increased from less about 400 ppm to about 750 ppm. By 1992, the Euphrates' salinity at Al Qaim reached 800 ppm.

Further downstream, at Ramadi (Fig. 6) the salinity has increased from 400 ppm in 1984 to about 820 ppm in 1990, while in Fallujah (Fig. 8), the salinity was increased from 600 ppm in 1980 to 1,200 ppm. At Al Hindia (Fig. 9), the salinity has increased to about 1,200 ppm as measured in 1990.

According to Figs. 4-9 discharge has a considerable effect on water salinity when the discharge increased the salinity decrease and vise verse therefore the authors

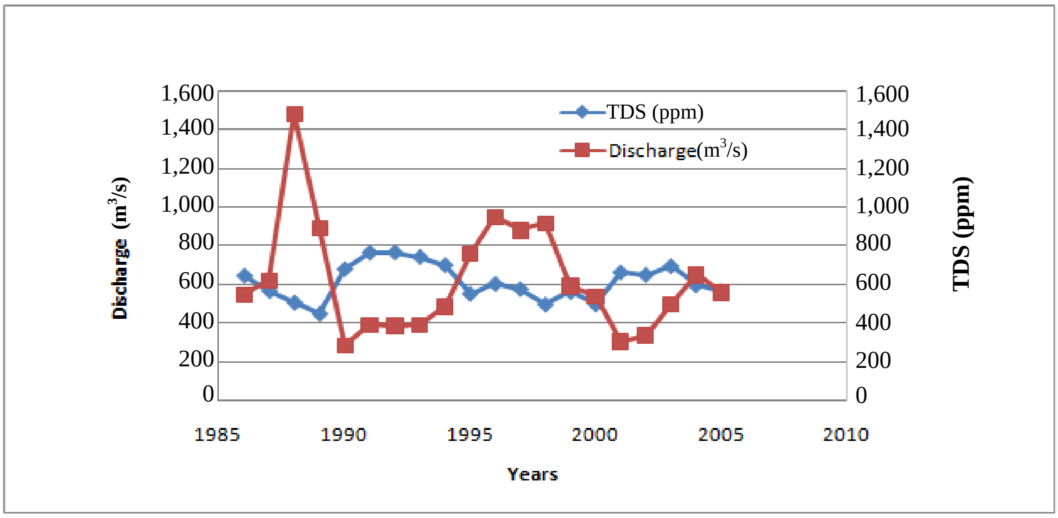

Fig. 4 **Salinity and discharge at Hussaiba (1986-2005) (researchers, data from Ref. [7-12]).**

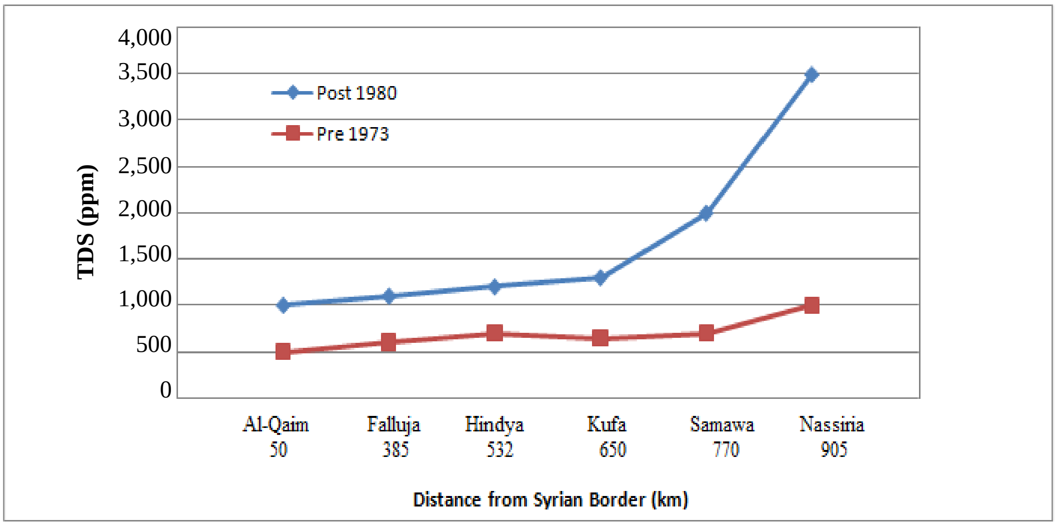

Fig. 5 **Salinity along the Euphrates course prior to 1973 and after 1980 as extracted from Ref. [5].**

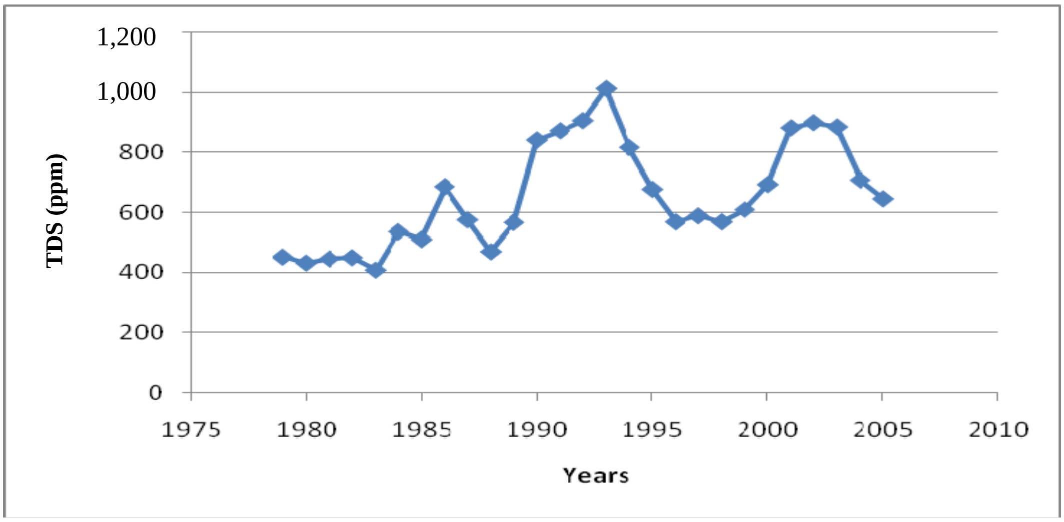

Fig. 6 **Salinity of Euphrates River at Ramadi (1975-2005) (researchers).**

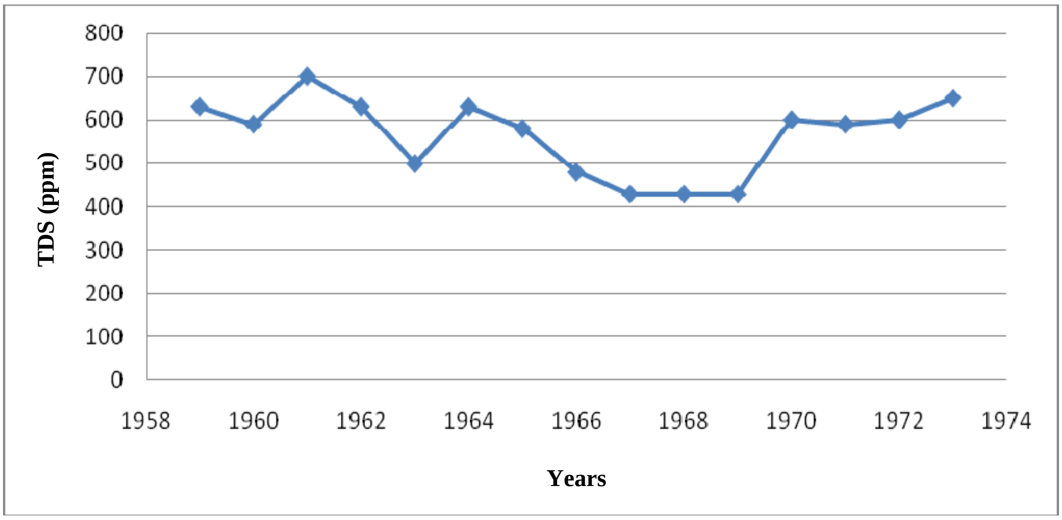

Fig. 7 Mean annual TDS at Fallujah Gauging Station (data from Al-Hadithi [6]).

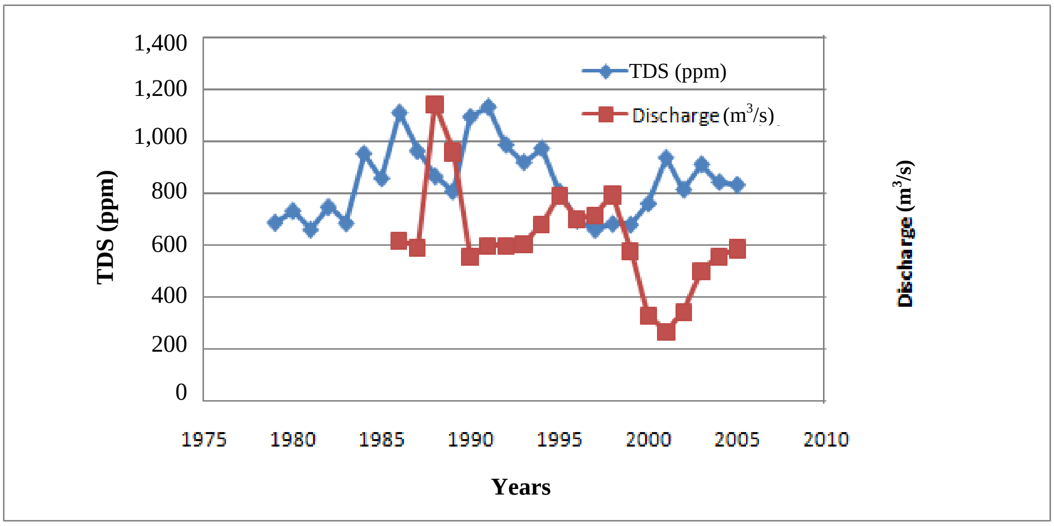

Fig. 8 Salinity and discharge at Fallujah (researchers).

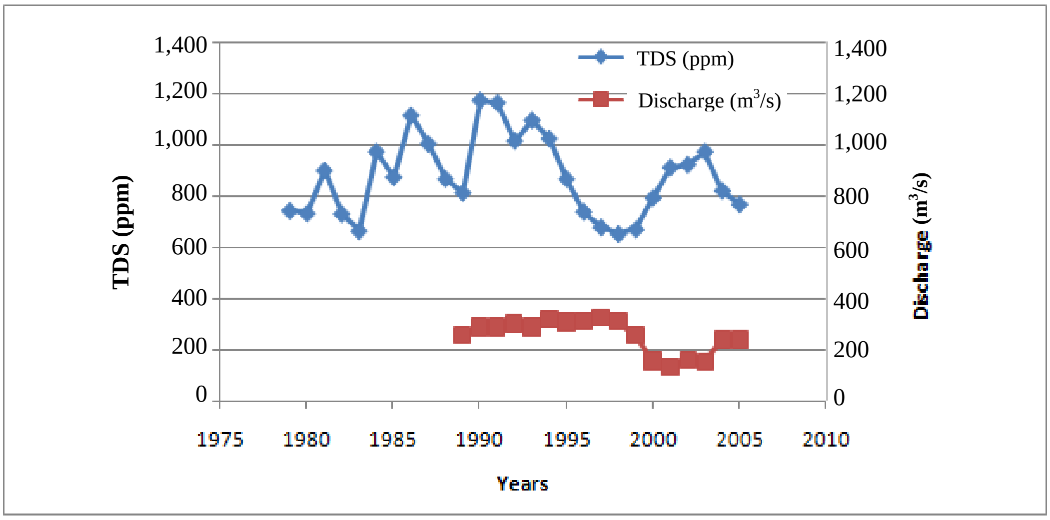

Fig. 9 Salinity and discharge at Hindya (researchers).

must balance between discharges from Haditha dam and salinity along the river. Fallujah station has very high salinity because the effect of Tharthar-Euphrates channel.

3. The Effect of Storage in Tharthar Lake on Water Quality

Al-Tharthar Lake is the biggest lake in Iraq and located 65 km to the north west of the city of Baghdad (Fig. 1). It is the one of the most important flood control and storage project in Iraq, which protects the city of Baghdad and other cities from flood hazard. The maximum capacity of the reservoir (lake) is (85 × 10^9 m^3, the length of it is about 100 km with 40 km wide. For storage purpose, the channel of Tharthar-Euphrates was achieved with 37.5 km long and discharge is 500 m^3/s in 1976 and Tharthar-Tigris channel with 23.5 km long and discharge is 600 m^3/s in 1988, then the total discharge became 1,100 m^3/s, there are important flood control and storage water.

The construction of Tharthar lake reservoir has two man aims:

(1) Flood control;

(2) Water storage for irrigation use in twin rivers plan.

The Tharthar depression made possible the accumulation of water by escape samara-Tharthar canal for diversion of flood Tigris water. First water from Tigris has been diverted to Tharthar depression in 1957. From that time the Tharthar depression had been filled up to 1969, reaching the elevation of water level +60 m. The escape canal from Tharthar reservoir for diversion of water to Euphrates and Tigris has not yet been constructed. During this period of existing of the Tharthar reservoir an enormous amount of salts have been accumulated.

Energo project (1970) in his preliminary report “increase of salt concentration in the Tharthar Lake” made the salt balance in this water storage, after 13 years of the filling Tharthar depression with diverted water from Tigris River. It staffed that along above mentioned factors, the evaporation appears as an additional factor contributing the salts accumulation. Namely, a tremendous amount of water has been evaporated, and consequently the salt concentration gradually increased. Fig. 10 indicated an approximate contribution of various factor in the increase of salts concentration in Tharthar lake water. Although the date from Fig. 10 shows the approximate values, it can be pointed out that the lixiviation has a remarkable effect on the salts accumulation, participating with 62%. According to our opinion, it may be that some other factors take place in salts accumulation in water of Tharthar Lake, as wind erosion, seepage of salty ground water from surrounding areas.

Fig. 11 shows the salinity of water that inter the lake from the Samarra barrages which indicates the maximum salinity as mean is about 450 ppm and minimum is about 200 ppm while, Fig. 12 shows the salinity and discharge from the lake to the Euphrates River. The salinity of the lake is about 1,000 ppm in 2005 which depends on the inflow water from Samarra barrages and this water discharge from the lake to Euphrates river at Fallujah (Figs. 13 and 14). To explain the effect of storage in Tharthar Lake on water quality, water salinity of Euphrates River was tested at Ramadi that indicates to 600 ppm in 2005 while the salinity in Fallujah (45 km from Ramdi) after the water inflow to the river from the lake is about 830 ppm in the same periods. Fig. 15 shows the increase of the salinity along the Euphrates river pre and post 1990, at Fallujah the authors can conclude the high increasing of salinity because of the income flow from Tharthar Lake and return of irrigation water.

4. Conclusions

The authors get the conclusions as following:

(1) The decreased inflow entering Iraq leads to the increased salinity content and there is a relation between the river discharge and salinity of water river, therefores the discharge from Haditha reservoir must

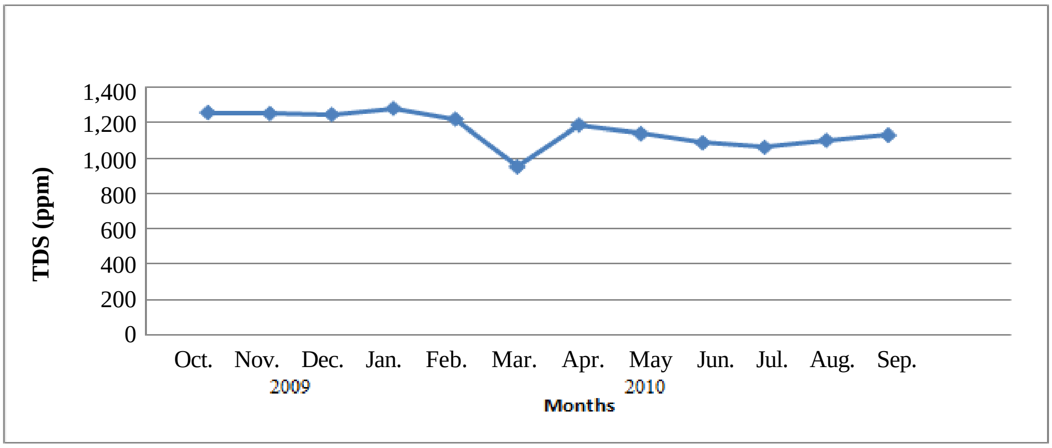

Fig. 10 **Salinity of Tharthar Lake (Researchers).**

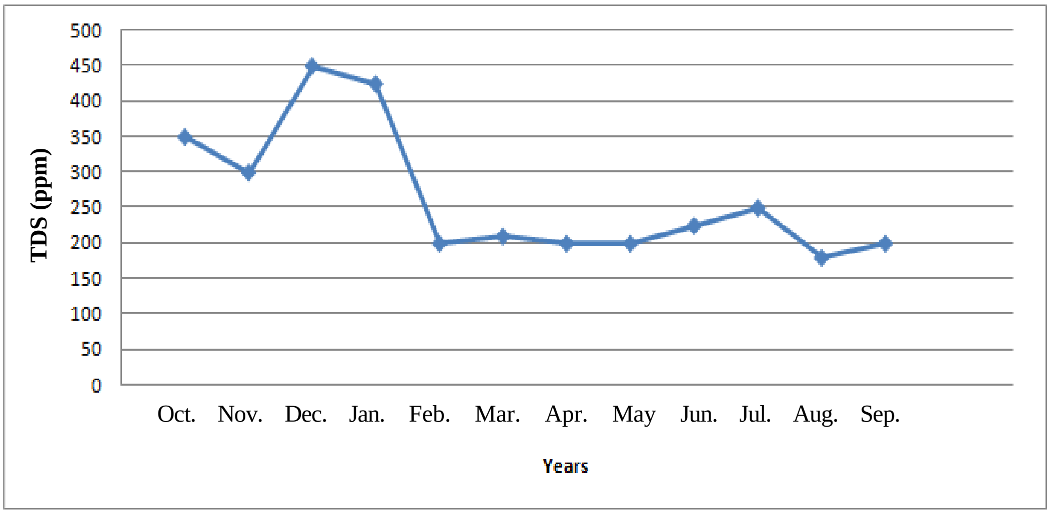

Fig. 11 **Salinity of Tigress River upstream Samarra Barrages (researchers).**

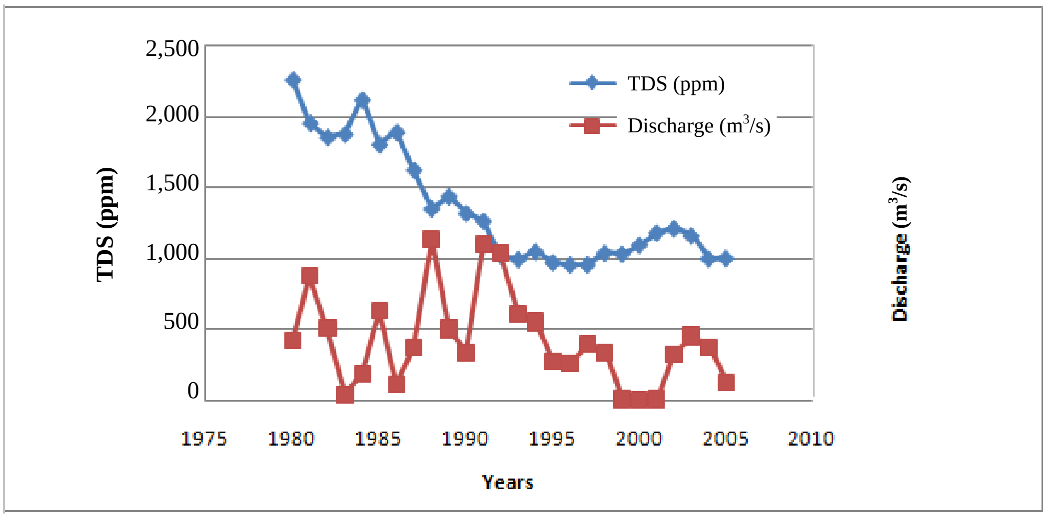

Fig. 12 **Salinity and discharge from Tharthar Lake to Euphrates River (researchers).**

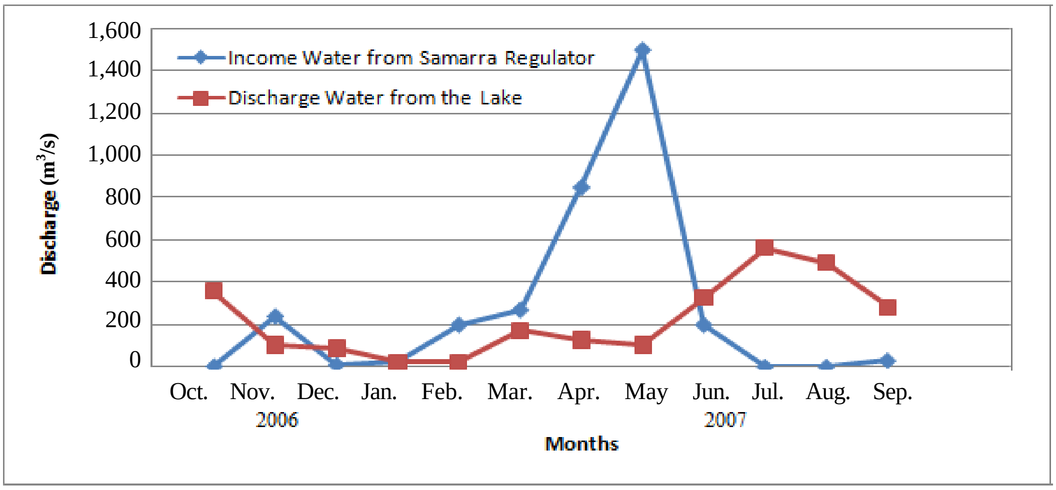

Fig. 13 **Income water from Samarra and discharge (0-1,600 m^3/s) from Tharthar Lake (2006-2007) (researchers).**

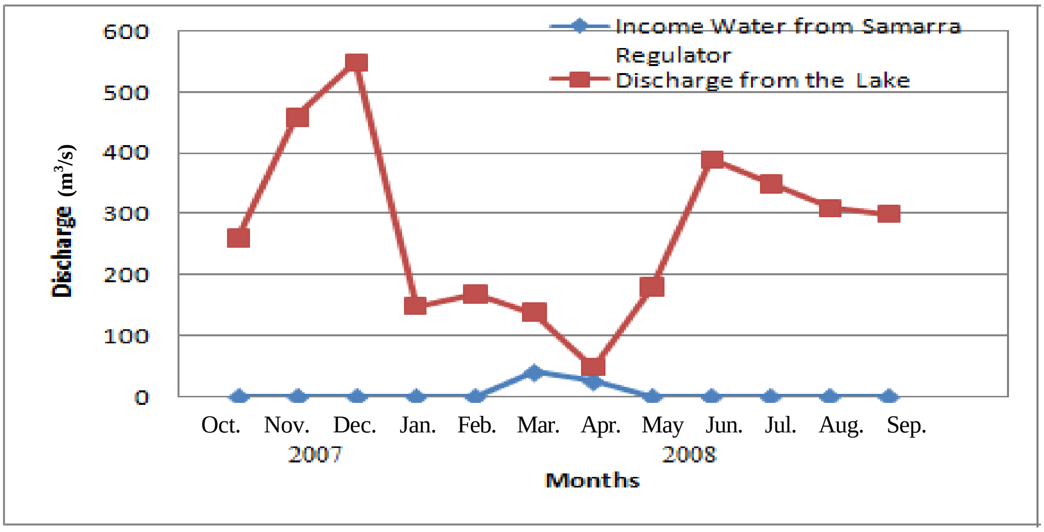

Fig. 14 **Income water from Samarra and discharge (0-600 m^3/s)from Tharthar Lake (2006-2007) (researchers).**

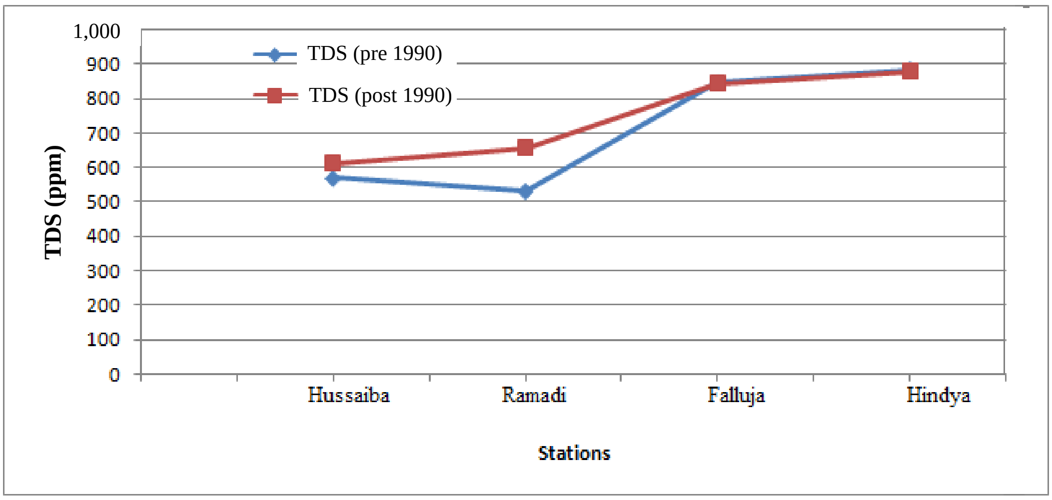

Fig. 15 **Salinity along Euphrates River Pre and post 1990 (researchers).**

be formulated according to desire salinity downstream reservoir;

(2) The flow diversion from the Tigris to the Euphrates via Al Tharthar Lake has negative effects on water quality of the Euphrates River because the high concentration of salinity of Tharthar Lake, therefore, the studies about practicability to diver inflow directly from Tigris to the Euphrates must be achieved;

(3) The irrigation return-flow into the river from Iraqi irrigation projects or redelivering of drainage water management must be treated.

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