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The low discharge simulation of the Shatt Al-Arab River and its influence on water quality

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Abstract - In the present research, a numerical model was developed using the software package Mike 11 to study the water quality of the Shatt Al-Arab river (TDS, DO, TSS). Three stations were selected at the upstream of River (Qurnah) in the middle (Ma›aqal) and downstream (FAO). A value of (50 m^3/sec) discharge was used in chain age (0.0 m) and time series file for heights of tides in chain age (240932.0 m) which was the implementation of the programme for one year after calibration and verification between field measurements and the programme outputs, they show that there is a good compatibility. On using the value (250 m^3/sec) to explore the impact of high discharge of river on water quality, this study shows that the discharge of the river plays the role of reverse with increase and decrease in these characteristics as well as the location of measuring stations on the estuary, in which all the values of variables are increased has an obvious effect. If the measurement station became closer to estuary that's lead to increase in the value for variables, because of the tidal river were the values for variables in some stations in flood case larger than of ebb case. The programme represents a first step towards preparing a programme containing more water quality variables. After the success of the programme, made it possible to calculate any of the three variables after knowing the value of the discharge of the river and enter the time series of tidal heights.

Key words: Discharge, Shatt Al-Arab River, Water Quality, Mike11.

Introduction

Conventional studies of riverine load concentrated form the basis of the amount of time the sediment flow to direct effects on the environment. However, the qualitative dimension of the riverine load (Quality Dimension) shows the importance of clear and growing in various environmental problems associated with many nutrients and contaminants in river load materials (UNWWAP, 2009) underscoring the need for continuous study of the qualitative characteristics of river load are studying the quality of river water and different characteristics factor in determining suitability for various uses. The degradation of these properties because of the lack of modern techniques for wastewater treatment and industrial which often take in route to the river water as well as seawater effect resulting in low quality Shatt Al-Arab river water for various usages. The evaluation of the physical and chemical properties of rivers are important as the importance of water can be valid for a particular use and non-valid for other use (Al Khaleefa, 2012).

The river is an important resource for the use of Basra Government, human, agricultural and industrial. The Shatt Al-Arab River originates from the confluence of the Tigris and Euphrates rivers and leading towards the Arabian Gulf in the southern direction. The Figure (1) features changing depths from one region to another, and the affected River basin hydrological conditions of the upper Tigris and Euphrates basins, tides from the Gulf. The most prominent scientific studies conducted on the river is the study conducted by the company. Nippon Koei (1972) in calculating water discharge and suspended load of the Shatt Al-Arab river at Al-Ma׳aqal port, and the study of Mohammad (1982) is as a theory to calculate River sediment burns to the Arabian Gulf and the contribution of the Karun River, while Karim and Salman (1987) to calculate the amount of sediment discharge in the Al-Ma׳aqal area and Fao, and dealt with a study Abdullah (1990) riverine load section North of the River at the city of Basra, and a study Al-Musawi (1992) the overall environmental conditions of the Shatt Al-Arab river and its effects on downstream waters, specifications, and dealt with a study Al-Mahdi (1996) the natural characteristics of the water course of rivers of Tigris and Euphrates and the Shatt Al-Arab river, Al-Hello (2001) conducted a comprehensive study of the Shatt al-Arab river and its various uses in Basra, and Abdullah *et al.* (2001) studied the physical and chemical properties of the Shatt Al-Arab in the northern part. While, Al-Fartusi (2013) prepared one-dimensional numerical model of sediment transported in the Shatt Al-Arab River using Mike 11 software package. There is an increasing interest in modeling and use it in guess, analyze quantities as proven by the high rates, on the other hand the cost mathematical models compared with conventional studies conducted be less. To assess water quality of any body of water and do field work and laboratory measurements of the physical properties, chemical and biological as well as possible to get results in record time. The current study is the first attempt to set up numerical model of one-dimensional using Mike 11 software Package some of the characteristics of quality of the Shatt River's current low the vicissitudes of time and perform the calibration process verification of the form with previous measurements.

Methodology

The Water Quality of Shatt Al-Arab river southern Iraq has been done. To achieve the objectives of the study, the steps that must be carried out are as follows:

Field Work:

The scientific team of Marine Science Center/University of Basra has carried out the water quality monitoring programs of the river during the period of Dec. 2012 to Nov. 2013 through a network of three stations. The monitoring of water quality at the 3 stations was performed by twice a month. The first measurement stations were selected with coordinates (30 º 59 ´ 41.69 ″ N, 47 º 28 ´ 15.38 ″ E), the second on the site (30 º 34 ´ 7.92″ N, 47 º 47 ´ 3.39 ″ E) and the third section at (29 º 59 ´ 23.73 ″ N, 48 º 27 ´ 52.75 ″ E) (Fig. 1). The device Acoustic Doppler Current Profiler (ADCP) has been used to measure the speed of currents, measure discharge water and tidal cycle duration (13 hours) at all stations, as well as water samples collector inverter device type Niskin Bottle Sampling Model 1080, with split section of the River to three locations on the two shores and the middle. Water mixture samples were collected with the suspended sediment from three locations and three deeps (surface, medium, 1 m from the bottom) at each hour over a tidal cycle.

For the purpose of establishing the water quality of the rivers, a total of 3 water qualities were selected, covering upper, mid and lower regions of Shatt Al-Arab river. During each sampling, in situ measurements of Dissolved Oxygen (DO), Salinity and Total Suspended Solids (TSS) and at the same time collected of approximately (234 sample) of measurement stations. As plastic bottles have been saved in the parameter and washed with distilled water (600 ml) and saved until the transfer to the laboratory. Filtration method has been used to calculate the concentration Total Suspended Solid (TSS) (Drake, 1974; Milliman *et al.*,1983), by taking a volume (250 ml)) of the sample after the shake well to distribute the suspended sediment on the volume evenly. This volume was filtered using an electric filter and a known weight paper from type (Millipore 0.45 µm). After finishing the filtration, the distilled water was added more than once to remove salts from the sample ,then placed in the Desiccator until the papers was cooled at room temperature and then weigh again for extract the concentration of (TSS). Use Total Tide software technique UKHO (2003) to see water level rises in the study area.

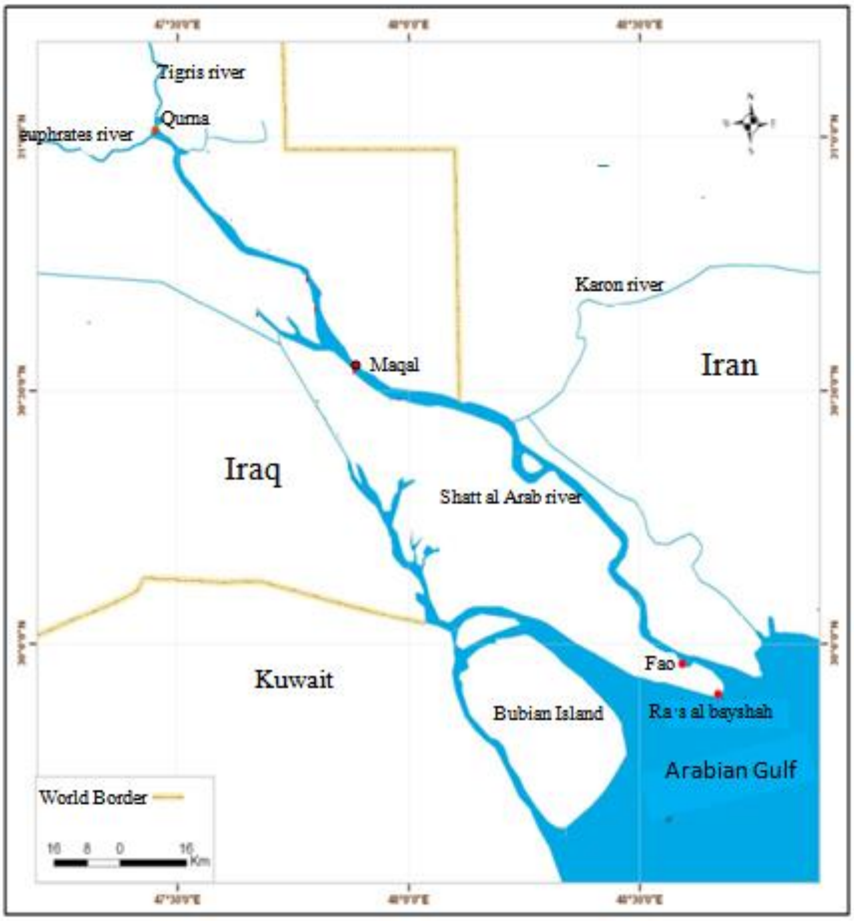


Figure 1. Study area and measurement stations (The researcher work)

Model Description:

Mike 11 is a one dimensional modeling system developed by Danish Hydrologic Institute, which is capable of simulating the hydrodynamics properties, water quality and sediment transport in rivers, estuaries and channels (DHI, 2007). It's performed an implicit finite difference computation of unsteady flow based on the Saint Venant equations described below:

$$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=q \quad (1)$$

$$\frac{\partial Q}{\partial t}+\frac{\partial\left(\alpha\frac{Q^2}{A}\right)}{\partial x}+gA\frac{\partial h}{\partial x}+g\frac{n^2Q|Q|}{AR^{4/3}}=0 \quad (2)$$

where, Q = discharge, A = cross-sectional area, h = water surface elevation above an arbitrary horizontal datum, n = Manning's coefficient of roughness, R = hydraulic radius, g = acceleration of gravity, α = kinetic energy coefficient (α =1.041), x = distance along the watercourse and t = time.

Advection-Dispersion Module (AD):

The AD module applied in the study could solve the advection-dispersion equation for dissolved or suspended materials. As input, the module relied on the spatial and temporal output from the HD module in from of discharge, water level, cross sectional area and hydraulic radius.

In the advection-dispersion module. The basic equation is the one-dimensional advection-dispersion one (DHI, 2007).

$$\frac{\partial AC}{\partial t}+\frac{\partial QC}{\partial x}-\frac{\partial}{\partial x}\left(AD\frac{\partial C}{\partial x}\right)=-A\lambda C+C_2 \quad (3)$$

Where: C = Concentration, D = dispersion coefficient, λ = linear decay coefficient (λ = 0.08) and C_2= source/ sink concentration

Model Application:

Hydrodynamic module (HD):

The HD is the core of the system, contains an implicit finite difference computation of unsteady flows in river. Engineering study area established in one dimension in network file (network 11). It deals with actual data grid (Eastern and Northern points of study area). Satellite image at the 38 zone of southern Iraq was used to obtain the actual coordinates grid of network file. Figure (2) illustrates the use of the satellite image of the area of study of dimensions (X = 680,000; 880000, Y = 3250000; 3530000). Began the process of networking from the Tigris River at the site of Alkasara barrage in Maysan province with geographical coordinates 47° 01 ' E ' and 31 54.57 ° 21 ' 38.16″ N and extended along the Shatt Al-Arab to Ra's Al-Bishah with geographical coordinates 48 ° 48 ' 00 "E, 29 ° 44 ' 24″ N as well as networking is linked with the Euphrates River from embankment on the River to the confluence with the Tigris River at the town of Qurnah. A spatial step used was between the distribution points and all branches the amount (Δx = 500 m).

The bathometry model was set up using 224991Raw cross sections along the Shatt Al-Arab river and 33 to Euphrates River (Fig. 3). The cross sections that used in this study were obtained from a survey done by the Marine Science Centre, the University of Basrah, MSC (2006) where field data was measured according to the

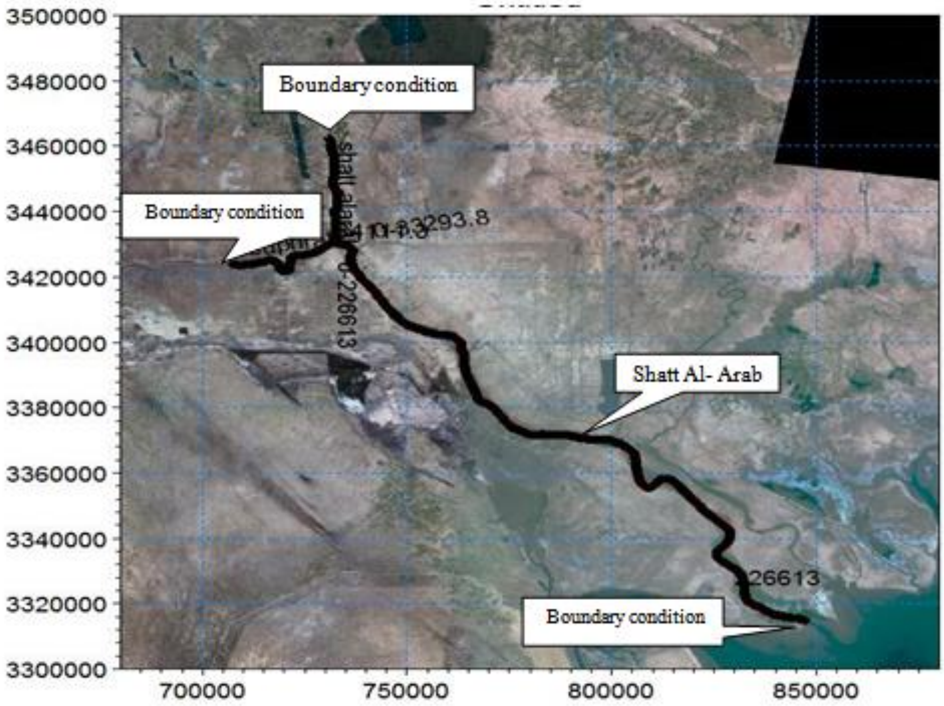


Figure 2. Shatt Al-Arab River network by MIKE-11 (Land Sat TM + 2013)

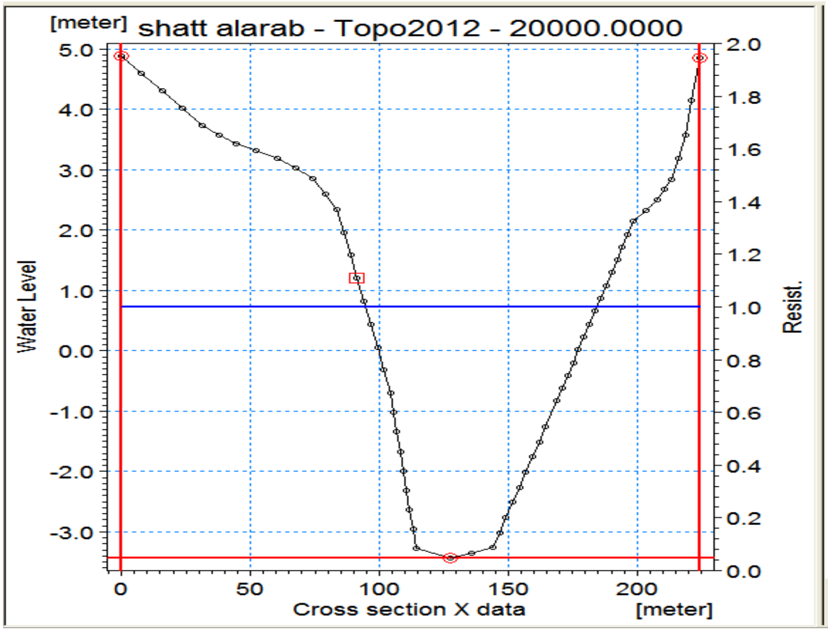


Figure 3. Raw cross sectional data of Shatt Al-Arab river.

specifications of IHO (IHO, 2008) where those data relative to mean sea level (MSL) and depends on the direction of the water flow in the order measurements (from East to West). Use boundary condition type open at both ends of the river discharge value was fixed at the beginning of the River (upstream) which equals (50 m^3/s) site at chain age (0.0 m) when Alkasarh barrage on the Tigris River, which was fed only to the Shatt Al-Arab River this time, either at the end of the River (downstream) on the site chain age (240932.0 m) at Ra's Al-Bishah may enter a file time series of tidal data for the time period (2012-2013) readings UKHO (2003) as shown in Figure (4).

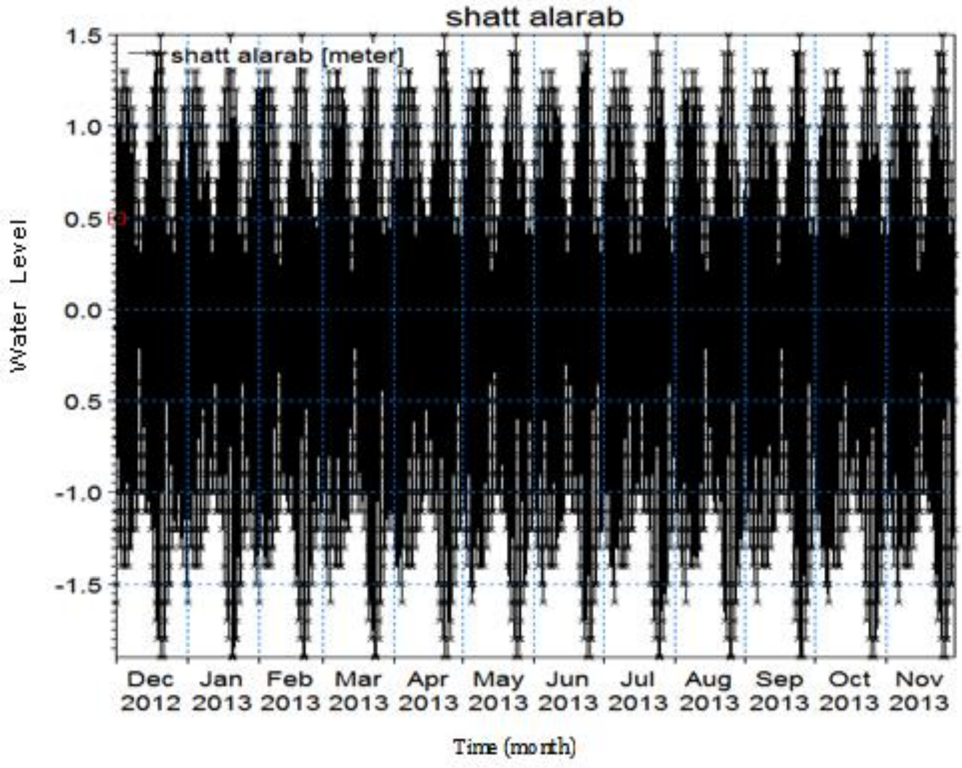
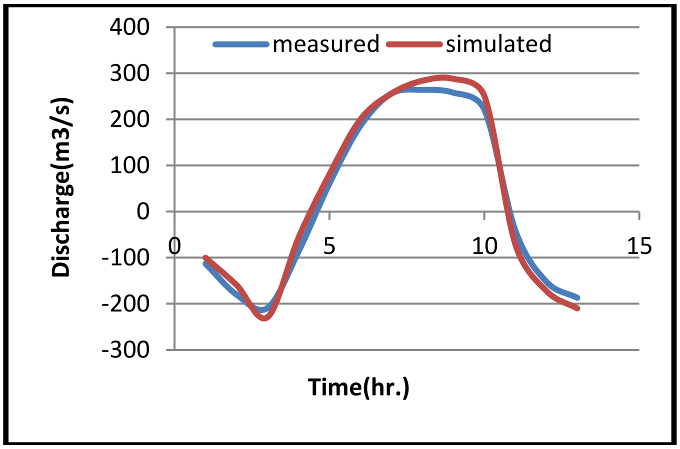


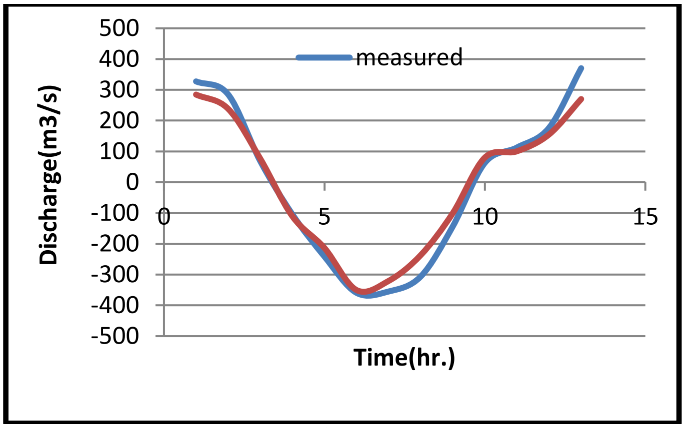
Figure 4. Water level fluctuations in downstream of the Shatt Al-Arab river (UKHO, 2003).

Results and Discussion

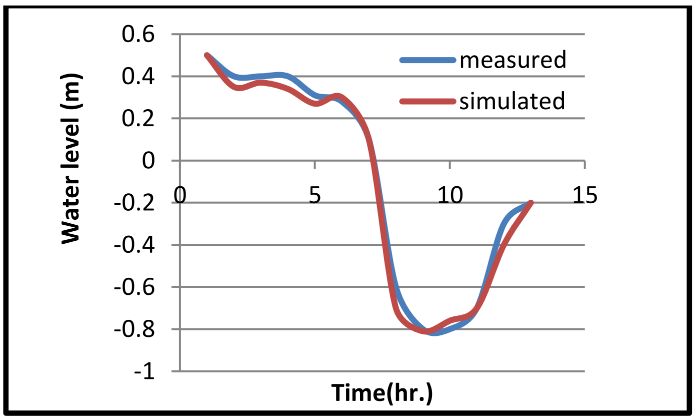
The program has implemented a time (Δt = 100 sec) and spatial interval (Δx = 500 m) for one year period, interspersed with field measurements. The value (0.024) of Manning roughness co-efficient of Shatt Al-Arab river was entered Buringh (1960). To verify the validity of the hydrodynamic model was compared with our measurements in field measurement stations in terms of water discharge and water level for two phase, spring and neap tide and tidal cycle complete 13 hours (Fig. 5).



Qurnah (neap)

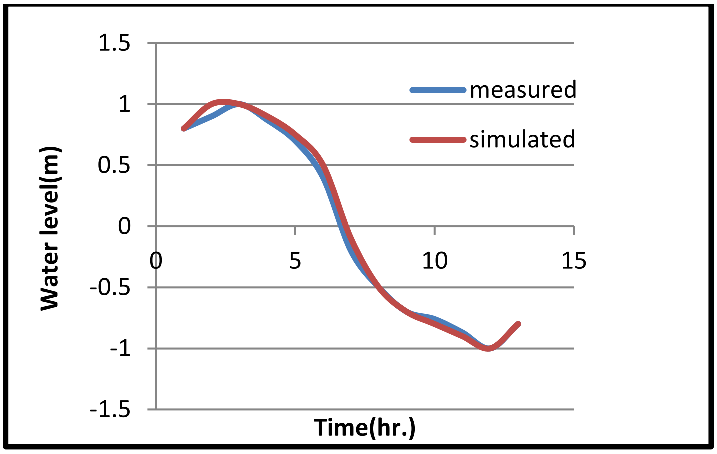


Qurnah (spring)

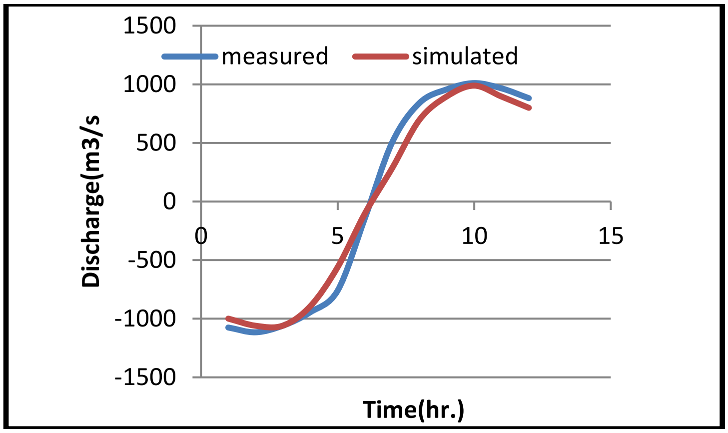


Qurnah (neap)

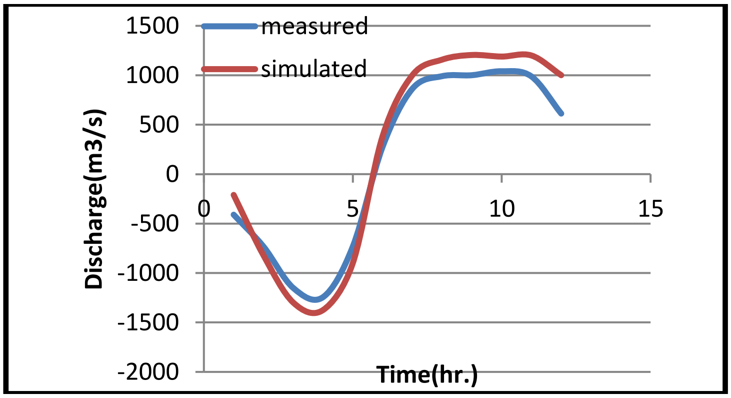
Figure 5. Comparison between simulated and measured discharge and water level at stations for two phase.



Qurnah (spring)

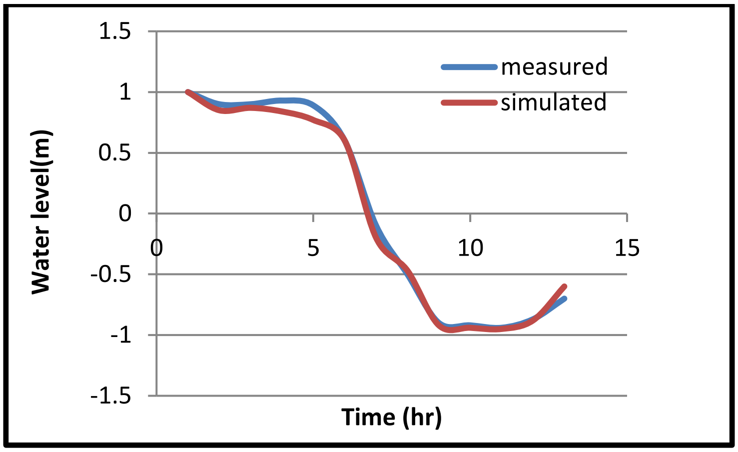


Ma'aqal (neap)

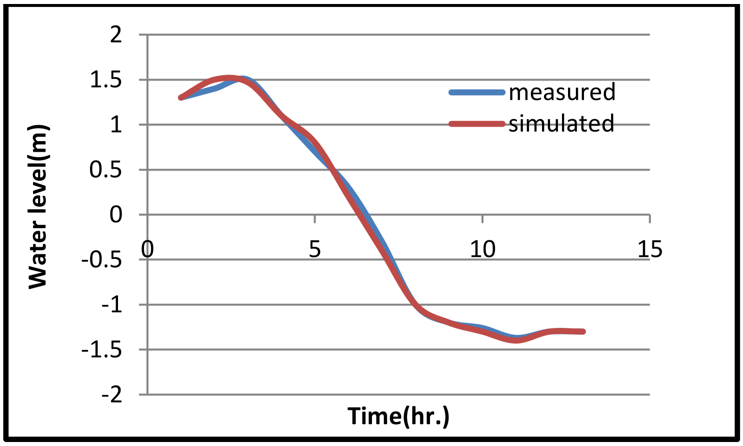


Ma'aqal (spring)

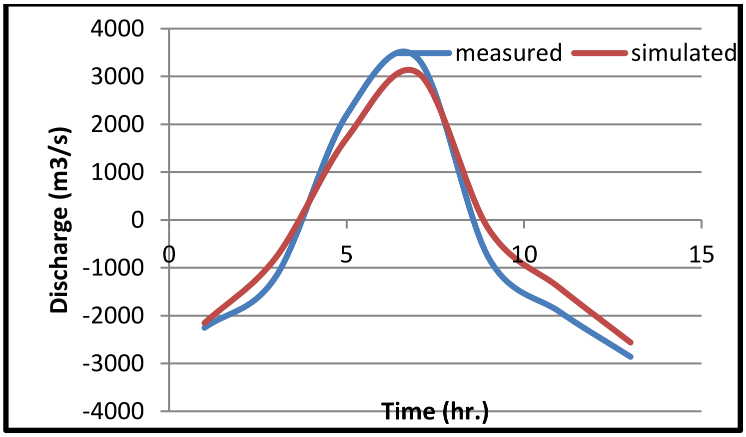
Figure 5. Continued ...



Ma'aqal (neap)

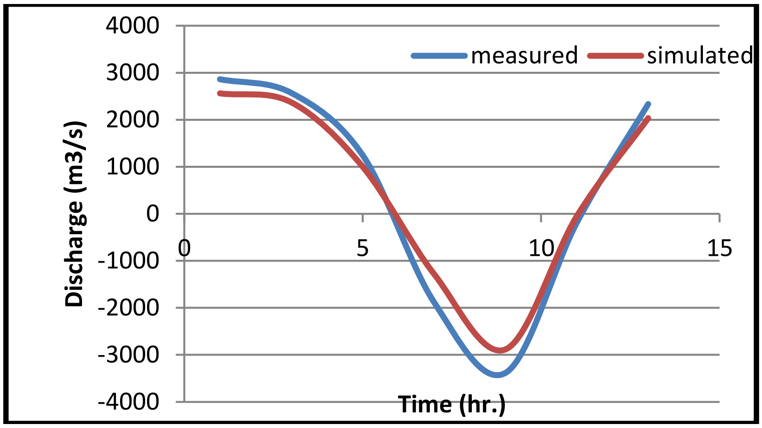


Ma'aqal (spring)



Fao (neap)

Figure 5. Continued ...



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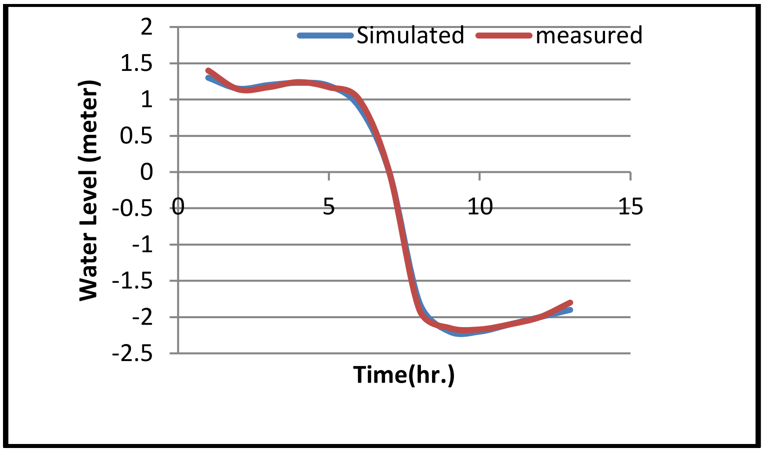

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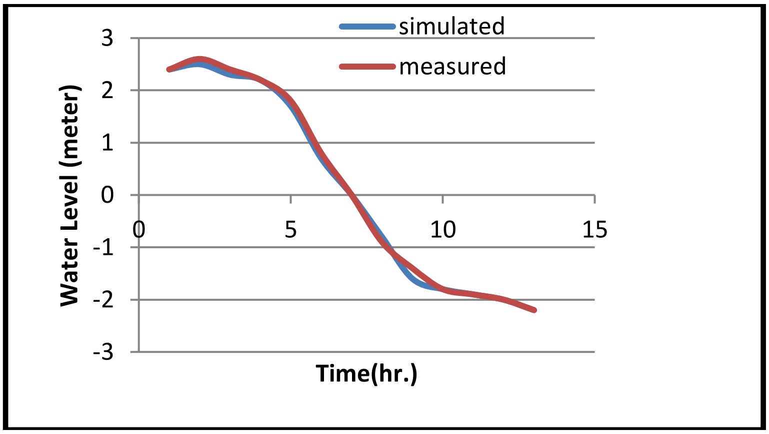


Fao (spring)

Figure 5. Continued ...

After verifying the success of the hydrodynamic model, it was adopted as the basis for water quality model for the study area. Average values were introduced some elements of the water quality of the Shatt Al-Arab in the Mike11 programme (chaninge 0.0 m) and chaninge (240932.0 m) was the implementation of the programme for one year on the same conditions existing river runoff so river discharge value (50 m^3/s).

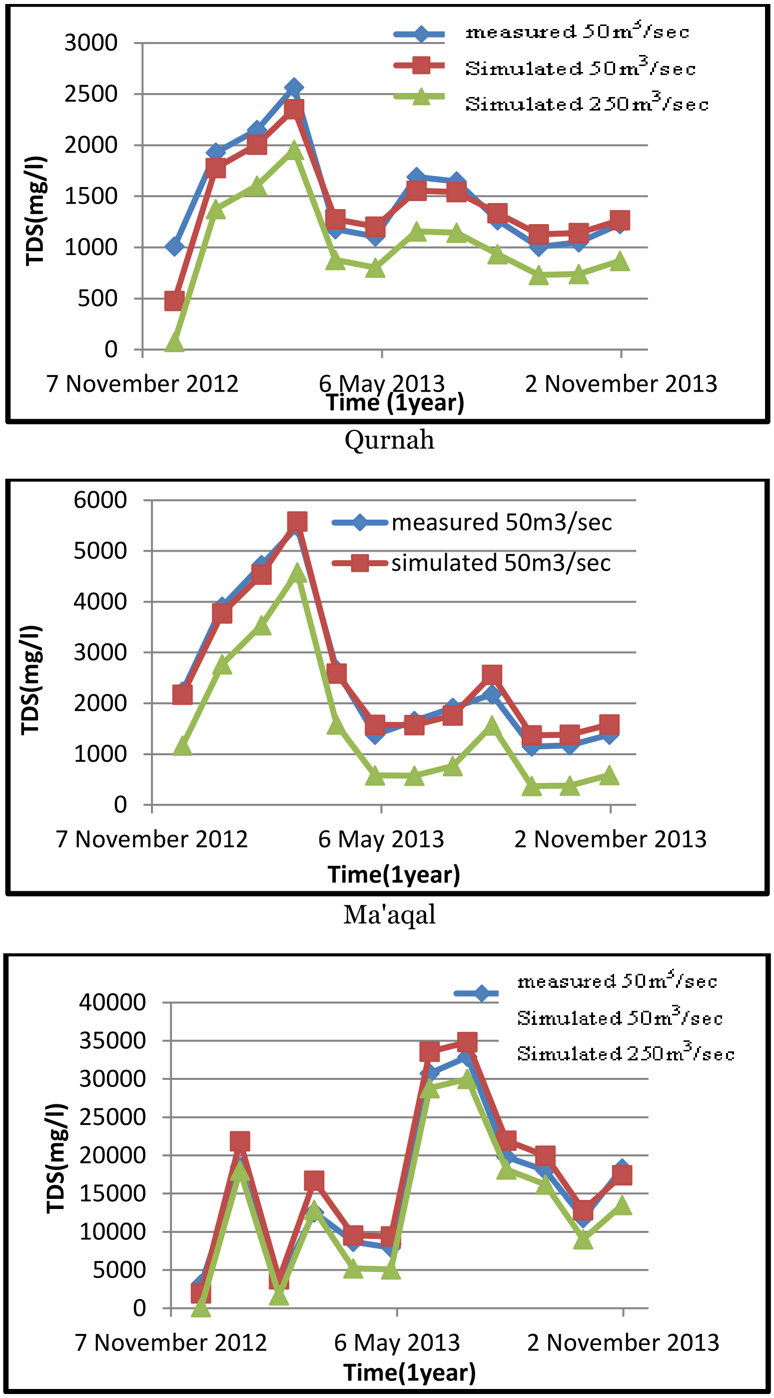
Then, we compared the results of the programme with our field measurement, Figures (6) shows how the correspondence between field measurement and simulation which was good.

The physical and chemical characteristics are the most important characteristics that must be relied upon to determine the validity of the water for human use ،agricultural and industrial, qualities evaluated periodically to give a clear impression of the extent of improvement or deterioration of the water. The existence of values for the discharge of fresh water (50 m^3/sec), a discharge current of the river, found that the dissolved oxygen values have shown a clear reduction during the study, reaching the lowest in the second and third station, and these values are considered critical suggesting water degradation and perhaps the reason was due to the increase of pollutants, especially organic that stimulate microbiology and thus the consumption of large amounts of oxygen for the purpose of breaking the organic material and this was consistent with the Moyal (2014). As in the first station was the largest for the lack of the presence of organic waste industrial or agricultural focus and concentration in the pan stations worth no different in the case of tidal value than in the ebb.

The TDS values increased in all stations as well as the increase in the values occur during the months of the low discharge (the month of December) and the decline in values during the months of higher discharges (April), during the year based on the nature of the hydrological Shatt Al-Arab river, this was consistent with the Al-Mahmood (2009).

As it seems clear that the increase in the values of Total Dissolved Solids (TSS) occurs as we move away from the first station and the second towards the downstream to the third station and this corresponds to what was found Abdullah (1995), because of its proximity to the estuary in addition to the density of population in the south of Basra, more than the north, as well as farmland drain in addition to tides that play an important role in the estuaries and tidal rivers in the environment changes at the physical and chemical parameter values, which was found that TDS is the biggest values in the case of ebb at the two stations first and second, either its value in the third station is the largest in all cases of its value for the two stations above. due to lack of discharge leading to the entry of a large amount of salt water and progress toward (upstream).

Characterized the relationship between the discharge and TSS by inverse relationship due to the nature of the river, where Shatt Al-Arab represents the final stage of the Tigris and Euphrates rivers, besides the nature of the tides. The concentration of total suspended at the first station was low, since it depended on the amount of material coming from the Tigris only because the Euphrates river is currently closed, and that the concentration is not much different in the case of tide or ebb, because the station far from the impact of the tide that coming from the Gulf.

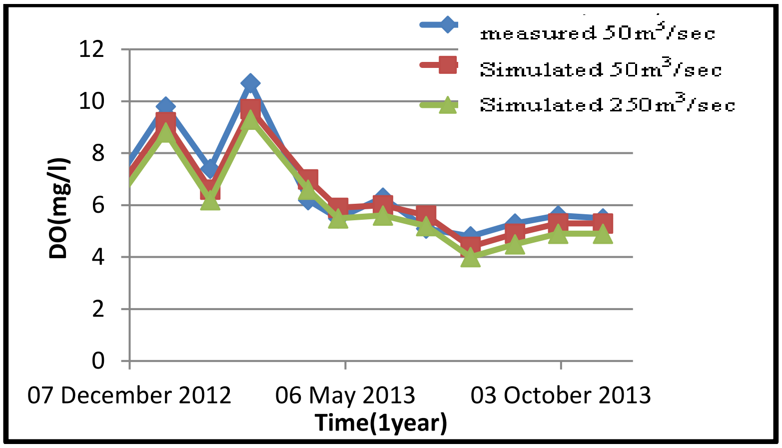


Qurnah

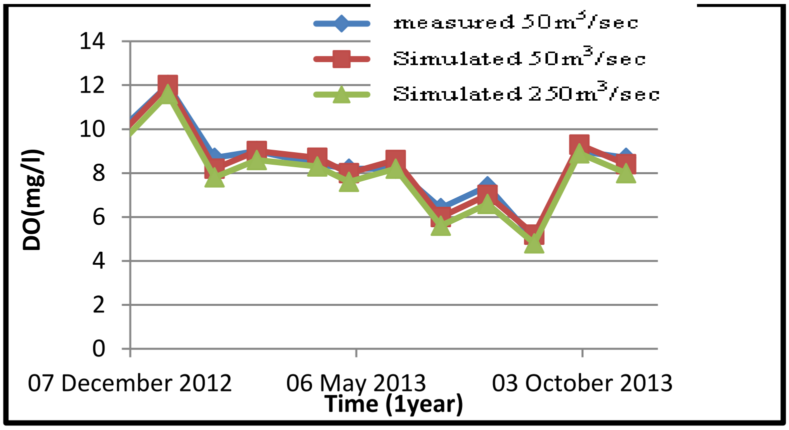
Ma'aqal

Fao

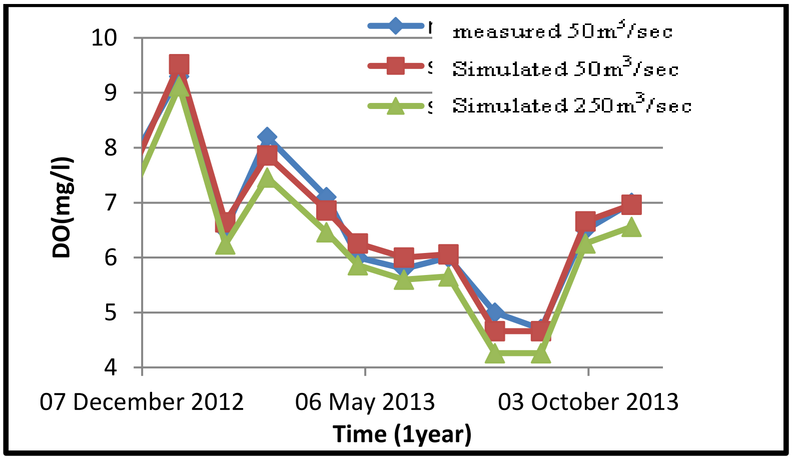
Figure 6. Comparison between simulation and measurment at (50 and 250m3/sec) at Three stations.



Qurnah



Ma'aqal



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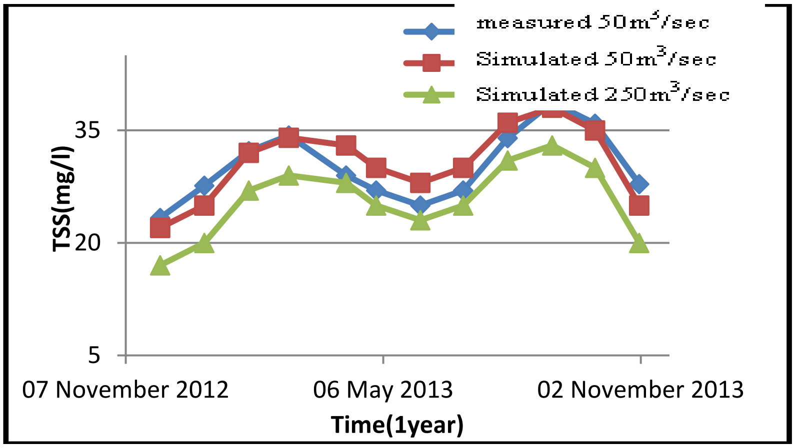
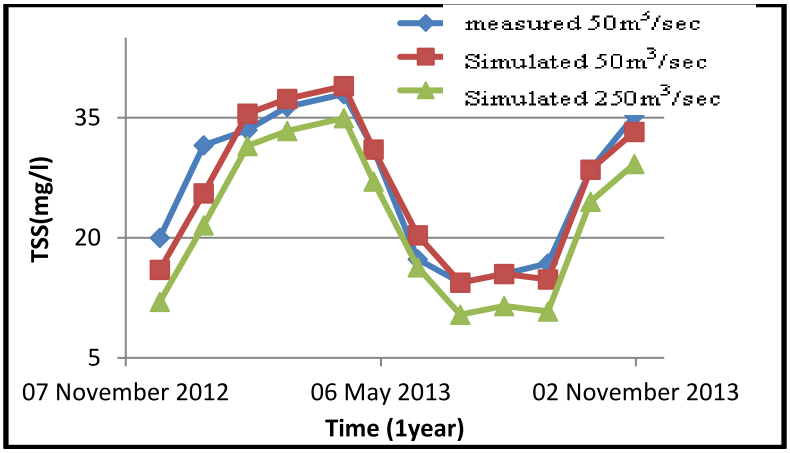


Qurnah



Ma'aqal

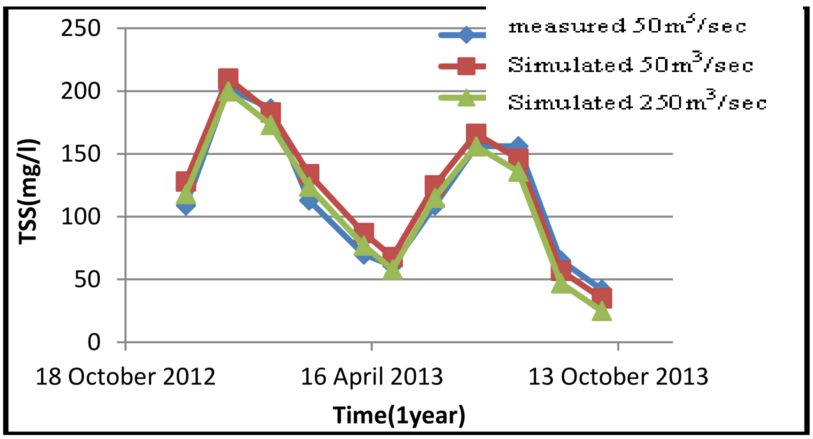


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Figure 6. Continued …

The concentration at the second station is greater than the first, because there are number of rivers and sub-channels that nearby and affected by the phenomenon of the tide.

The value of the concentration in the case of ebb is the largest, because of the length of the period that reach almost seven hours, compared with tide period which is less than six hours.

The third station recorded the highest concentration of the other two stations, due to proximity of the estuary, in a state of tide greater than from the case of the ebb, and this because of the low discharge in addition the course of the Karun River changed to Bahamshir channel in the Iranian side, which was transporting large amounts of sediment to the Shatt Al-Arab river in the case of the ebb, which reaches almost to half of the monthly revenue. This was consistent with the study conducted by Al-Mansouri (1996).

The value of (250 m^3/sec) of the discharge was introduced to the program and then simulated for a whole year to know the effect of high discharge on the water quality and the results were drawn as in Figure (6).

Characterized the relationship between the discharge and the (TSS and TDS) counterproductive. This was due to dilution process, which occurs in the case of high discharges, and in terms of the site whenever the station is closer to the estuary's mouth will be the concentration was biggest.

In the case of the low discharge the phenomena of (Dilution Process) does not occur due to lack of water and thus there was enough time for contact between soil and rocks with water, leading to increased concentration of salts.

For the dissolved oxygen and influence by an increase of the discharge was not significantly different in all stations and that its value has increased than in the case of low discharge. The dissolved oxygen is heavily dependent on the station's location along the Shatt Al-Arab River.

Conclusion

The study in Shat Al-Arab river leads to the following conclusion:

1. The application of one dimensional hydrodynamics model by using Mike11 program has been used to study hydrodynamics behavior of Shatt Al-Arab river. The result of the model has an acceptable agreement with observations of the statues of water quality of most samples in Shatt Al-Arab river during the average water flow.
2. The prepared program can be used to predict these variables after the introduction of the discharge value of the river and thus saves us effort and costs in field trips and environmental monitoring.
3. Site of the study has a clear role in changes the values of the properties, especially the total dissolved solids and the suspended materials, where the values of these materials increase as they move downstream, besides to the hydrological nature of the study area has another role in these changes, either annual changes in characteristic values, it is mainly dependent on river discharge.
4. The phenomenon of tide of Semi-diurnal prevailing in Shatt Al-Arab River and the discharge of the river and the overlap between them affect the daily changes in the values of all properties.
5. Characterized the relationship between the discharge and the (TSS and TDS) counterproductive while the dissolved oxygen and influence by an

increase or decrease of the discharge was not significantly different in all stations but it is heavily dependent on the station's location along the Shatt Al-Arab River.

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محاكاة التصاريف المنخفضة لنهر شط العرب وتأثيرها على نوعية المياه

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المستخلص - تم إعداد أنموذج عددي بأستخدام حزمة برامجيات (مايك 11) لبعض خصائص نوعية مياه شط العرب (المواد الذائبة الكلية والاوكسجين المذاب و المواد العالقة الكلية). أختيرت ثلاث محطات على طول نهر شط العرب في بداية النهر (القرنة) وفي الوسط (المعقل) وفي المصب (الفاو). ادخل قيمة تصريف النهر (50 م^3\ثا) عند تسلل (صفر متر).كما ادخل ملف السلسلة الزمنية لارتفاعات المد والجزر عند تسلسل (220932.0 متر). تم تنفيذ البرنامج لمدة سنة كاملة وبعد المعايرة والتحقق تبين أن هنالك تطابق بنسبة عالية بين القياسات الحقلية ومخرجات البرنامج المعد. ادخلت قيمة للتصريف (250م^3\ثا) لمعرفة تأثير ارتفاع تصريف النهر على العناصر المدخلة لنوعية المياه . من خلال الدراسة تبين ان تصريف النهر يلعب دور عكسي في زيادة ونقصان هذه الخصائص كذلك بعد موقع محطات القياس عن مصب النهر له تأثير واضح، إذ كلما قربت المحطة زادت هذه القيم وبما أن النهر هو نهر مدي كانت القيم في بعض المحطات أكبر في حالة المد منها في حالة الجزر. البرنامج المعد يمثل خطوه أولى من أجل إعداد

برنامج يحوي متغيرات أكثر لنوعية المياه. بعد النجاح الذي حققه البرنامج المعد أصبح بالإمكان حساب أي من المتغيرات الثلاث بعد معرفة قيمة التصريف للنهر وإدخال السلسلة الزمنية لارتفاعات المد والجزر.