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Hydrodynamic simulation model of the Shatt al-Arab River 30.5N

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Abstract: In this study a mathematical model has developed to stimulate the amount of fresh water inlet and discharge from Shatt al-Arab River in Basra city 30.5° N south of Iraq. The data for this model are based on local measurement during the period 1/10/2012 to 31/12/2012. The results show that there are a good agreement between the measurement date and the simulation results from our model and there is an inverse relationship between the (fresh water and sea water) and the (discharge, time and the low, high tide).

Keywords: Water recourses , Hydrodynamics, Mathematical Model, Simulation

I. Introduction

Water use has been growing at more than twice the rate of population increase in the last century; It is predicted to increase by 50 percent between 2007 and 2025 in developing countries and 18 percent in developed ones, with much of the increased use in the poorest countries with more and more people moving from rural areas to cities [1]. Based on this the management of water resources has become essential to study the strategy of allocation of water quotas because the world of climate changes and increased need for water. To understand these phenomena we need mathematical models to simulate the hydrodynamic fresh water for rivers to provide great service to manage the natural resources. This Mathematical models based on the numerical solution of the Saint-Venant equations [2], are almost always used to model the different types of flow through the rivers see for example [3-10].

The Shatt al-Arab one of the important river systems in Iraq, which arises from the confluence of the Tigris and Euphrates rivers in the town of Qurna (70 km) North of Basra 30.5°N, is the last stage of the river system of the Tigris and Euphrates and the length of the River (204 km) from the confluence of the Tigris and Euphrates to its mouth in the Gulf figure. Several scientific studies were conducted to examine by setting up a mathematical model based on de-saint-venant equations to predict the hydraulic conditions of the Shatt al-Arab channel see for example [11-14]. Shahidi et al [15] Construct numerical modeling for prediction of the salinity in the estuary into the Shatt al-Arab, moreover Mahmoud et al [16], used hydraulic model to simulate aerodynamic behavior of the northern part of the Shatt al-Arab. We notice that when the dams and reservoirs build as Al-soib River Dam and the dam on the Euphrates River, this led to the changing nature of hydrodynamic regime of Shatt al-Arab, where the River depends now mainly on the Tigris river because the rest of the water fed by other rivers and streams (Al-soib and Euphrates and Garmat Ali and Al-karon) are closed by the Ministry of water resources in Iraq, which led to a decrease in discharge and tidal power is coming from the Gulf have more impact and increased salinity in river water [12]. In this work which is divided in two part, first part include the local measurement of the different parameters which affect the behavior of Shatt-Al-Arab and in second part we used our data to simulate the hydrodynamics properties of the river. The result shows a good agreement between our mathematical model and the local measurement data.

II. Theory

The flow of water through stream channels is a distributed process since the flow rate; velocity and depth vary spatially throughout the channel. Estimates of flow rate or water level at certain locations in the channel system may be obtained using a set of equations that define the conservation of mass and momentum along this channel. This type of a model is based on partial differential equations that allow the flow rate and water level to be computed as a function of space and time. From a theoretical standpoint, the true flow process in the river system varies in all three spatial coordinate directions (longitudinal, lateral and transverse) as well as time. If a three-dimensional system is used, the resulting equations (modified Navier-Stokes equations for channel flow) would be very complex, and would require considerable amount of field data, which is also spatially variable. In field applications, most of this data could only be described approximately, thus rendering the three dimensional solutions susceptible to data errors. However, for most practical purposes, the spatial variations in lateral and transverse directions can be neglected and the flow in a river system can be approximated as a one-dimensional process along the longitudinal direction (i.e., in the direction of flow). Saint-Venant Equations of channel flow that were derived in the early 1870s by Barre de Saint-Venant, may be obtained through the

application of control volume theory to a differential element of a river reach. The assumptions made in derivation of Saint-Venant equations of Channel Flow are:

1. The flow is one-dimensional. The water depth and flow velocity vary only in the direction of flow. Therefore, the flow velocity is constant and the water surface is horizontal across any section perpendicular to the direction of flow.
2. The flow is assumed to vary gradually along the channel so that the hydrostatic pressure distribution prevails and vertical accelerations can be neglected.
3. The channel bottom slope is small.
4. The channel bed is stable such that there is no change in bed elevations in time.
5. The Manning and Chezy equations, which are used in assumptions made in derivation of Saint-Venant Equations of Channel Flow the definition of channel resistance factor in steady, uniform flow conditions, are also used to describe the resistance to flow in unsteady, non uniform flow applications.
6. The fluid is incompressible and of constant density throughout the flow.

According to these assumptions the inflow to the control volume is the sum of the flow Q entering the control volume at the upstream end of the channel and the lateral inflow q entering the control volume as a distributed flow along the side of the channel i.e.

$$\text{Rate of change of mass} = \sum \text{mass inflow} - \sum \text{mass outflow}$$

This general equation of continuity can be given for the particular case of an open channel with an irregular geometry. The conservation of mass then can be written as

$$\rho(Q + qdx) - \rho\left(Q + \frac{\partial Q}{\partial x} dx\right) = \frac{\partial(\rho A dx)}{\partial t} \quad (1)$$

Applying the assumption of constant density and rearranging produces the conservation form of the continuity equation, which is valid for any irregular cross section

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q \quad (2)$$

And the momentum equation can be written as

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

Where Q = total discharge, A = area of cross section, q = accidental discharge = 'h' change the water level, n = Mannk factor for roughness, R = hydraulic radius of the Shatt al-Arab, g = gravity, a = motor power factor, x = distance along the riverbed, t = time

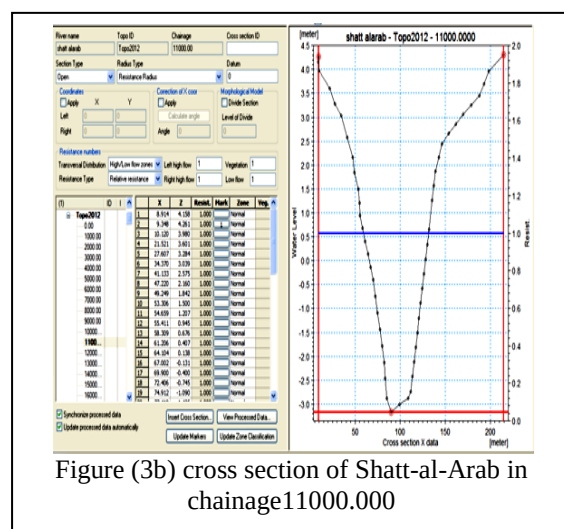
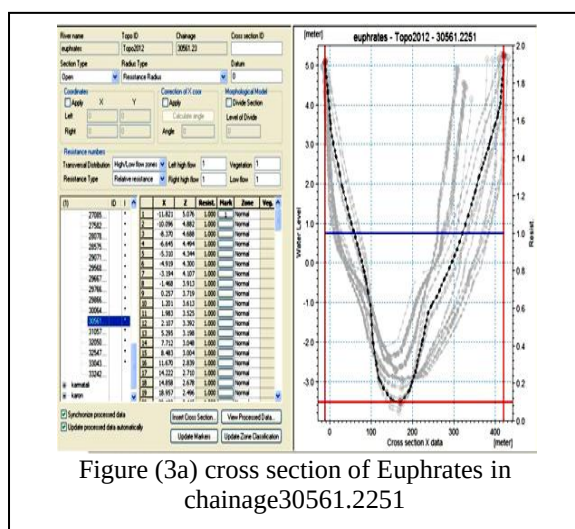
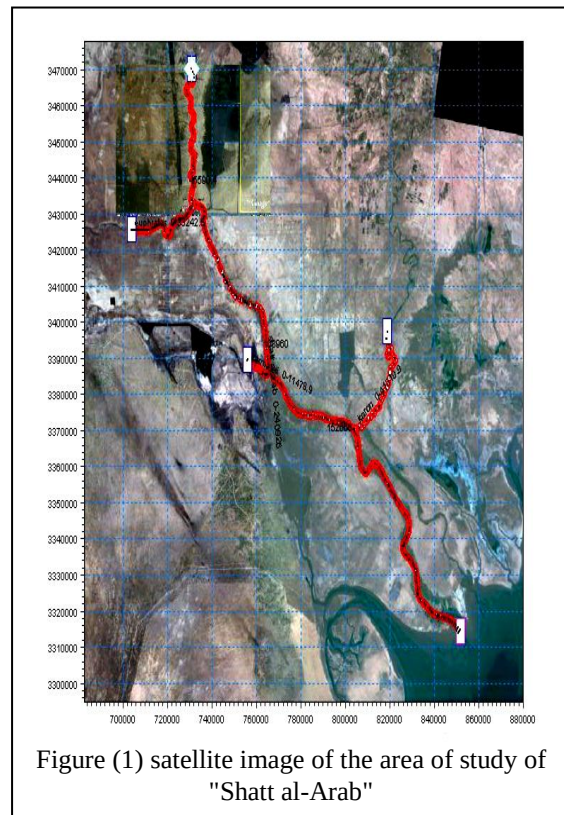
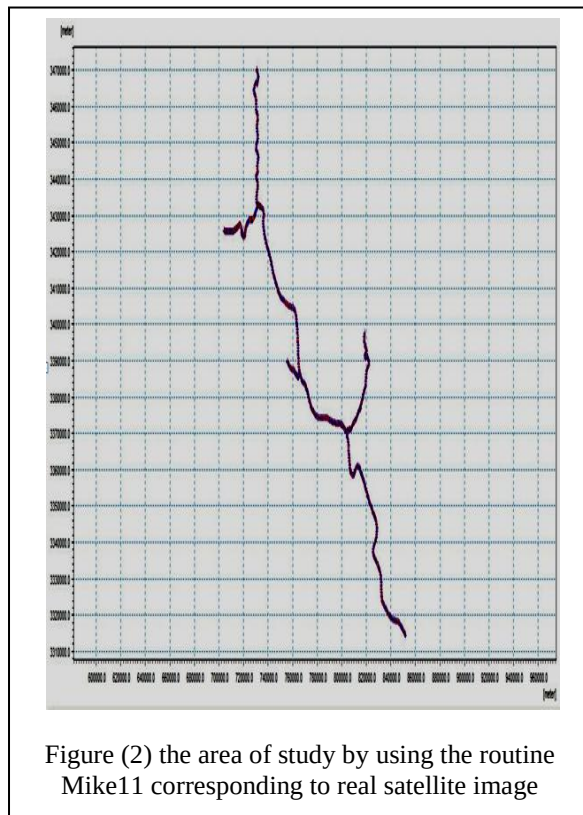
III. Result and Discussion

First we start by collection the data during the period of study and these data include:

- 1) The river is considering an open channel at the both ends. The value of the of the discharge of water at upstream (Chainage0.0 meter) is 80 m³/s, the word Chainage means the distance in meter from the up-stream point to any other point at the river, the downstream point at (chainage240000 meters) .
- 2) Measurements of the cross sections of the river "Shatt Al-Arab" at different location (FAO, Saybah and Abu al-Khasib)
- 3) Measurements the water flow velocity of the river during high and low tides for a complete tidal cycle which is 13 hours each day during the period of study at the above locations

The study established the channel geometry by using a computer program routine called Mike11. This routine deals with real data entry points in east and north of the study area. also we used the data collected from the satellite image of the area of study in south of Iraq as presented in figure (1). This image was corrected, rearranged by using the GIS system and then reproduced the image as presented in figure (2). The routine above also used to simulate the hydrodynamics movement of the amount of water to the Shatt al-Arab river during the period of study. The routine also solves the Saint-Venant equations these equations are the continuity and momentum equations in one dimension. The distribution of transects along the study area were used in a file called (xsc11) and the hydraulic changes for each (500 metres) depending on measurement data, for each section about (1) km along the study area. The number of sections are 45 along the River Tigris starting from Al-Kasara station, and the number of sections are (33) along the Euphrates River Starting from embankment constructed on River, and the number of sections (204) along the Shatt al-Arab Starting from the area of the confluence of the Tigris and the Euphrates to the RA's al-Bayshah area. Also there are (11) Sections along Garimat-Ali area, As well as (43) sections on the Karun River; all the above section are presented in figures (3a-3e). Figure (4) represent the time series of high and low tide data at Ra's Al-Bayshah area during the course of study where the simulation period is 30 days. To Check the model's simulation results compared at (chainage173,000) which represents a cross-section of the metering station in Abu al-

Khasib with results obtained in the field at same station and this comparison seem very well in term of the hydrodynamic behavior of the model results and field measurements as shown in figure (5). As a conclusion it is found that there is a comparable that the model worked well for process simulation and engineering physical variables of the study area. We need to select more sites and longer time periods other than that used for simulation and calibration for more accurate simulation. The results show there is an inverse relationship between amount of fresh and sea water with the discharge, time and tide. It was notes that the period of time low tide is shorter than the time period of the high tide. Our results are a major step to establish a model that simulates the water quality characteristics and strategic planning for water management in the Shatt al-Arab river, as well as establish a monitoring program and the changes of the hydrological conditions.



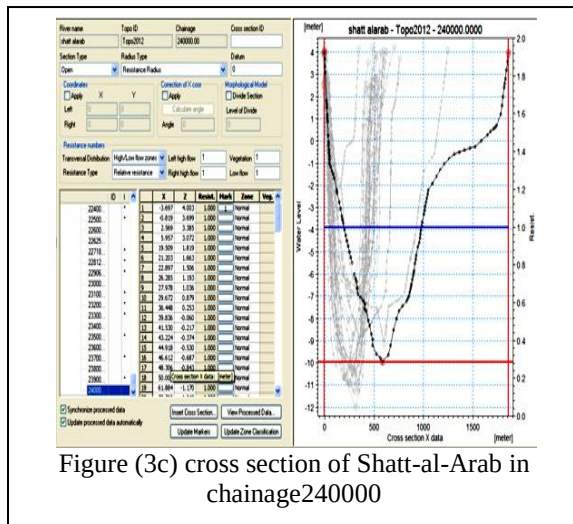


Figure (3c) cross section of Shatt-al-Arab in chainage240000

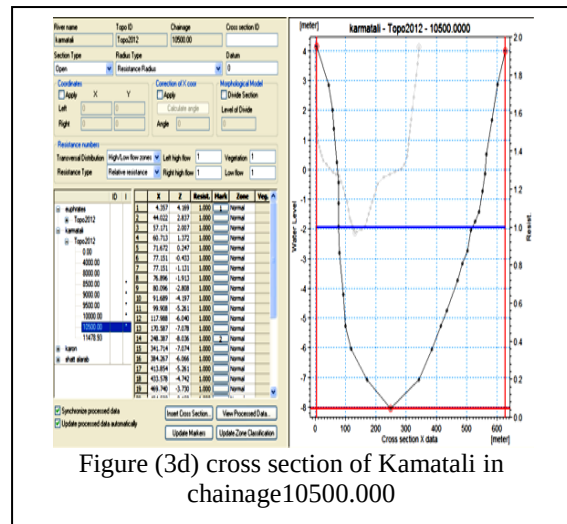


Figure (3d) cross section of Kamatali in chainage10500.000

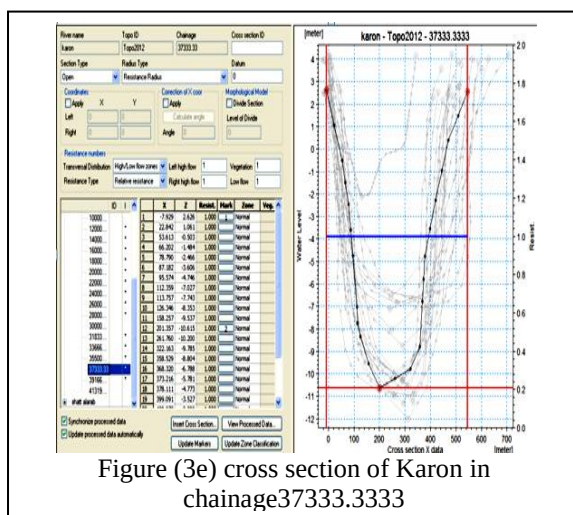


Figure (3e) cross section of Karon in chainage37333.3333

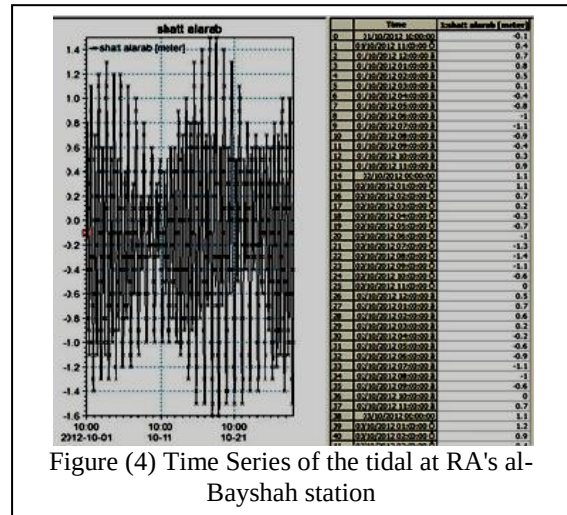


Figure (4) Time Series of the tidal at RA's al-Bayshah station

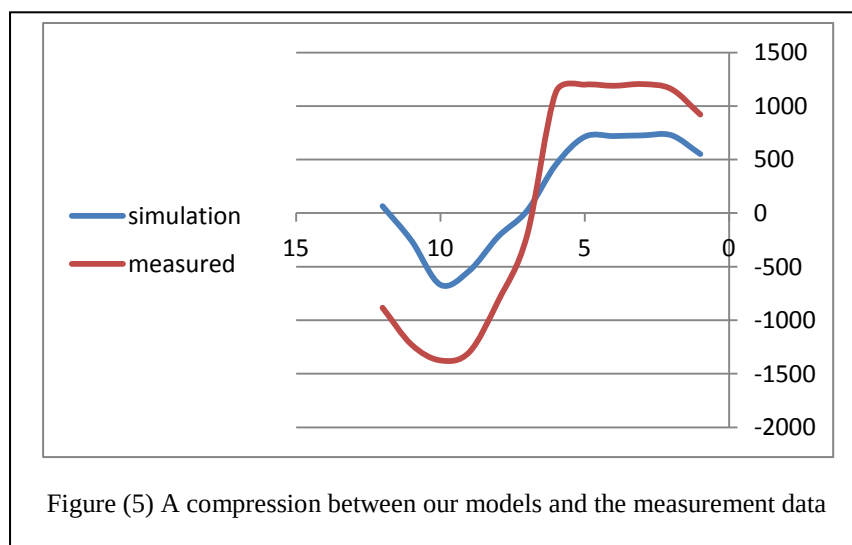


Figure (5) A compression between our models and the measurement data

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