



Climatic Factors and their Impact on the Stability of the Hydro-Dynamics Model of the Shatt Al-Arab River 30.5⁰ N

Adel Jasem Al-Fartusi¹, Noori Hussein Noor al Hashimi² and Samer Adnan Al-taie¹

¹Department of Physics of estuaries and marine water/ Centre for Marine Sciences/ University of Basra/

²Department of Physics/college of education for pure science/University of Basra/Basra/Iraq

Abstract: Shatt al-Arab River is one of the rivers affected by the phenomenon of the tides in the area of confluence with the Arabian Gulf. a promising Hydro-dynamics model to simulate the movement of water masses is developed with the help of Mike 11 routine. In this model the different weather factors introduced in order to insure that our model simulate the real conditions and facts of the study area. A field measurement data for the period's 15th-18th oct. 2012 and for the periods 27th-28th may 2013 has been used for the calibration purpose of the simulation result. This study has been carried out for two periods, the first period started on 1st oct. 2012 and end on 31 oct. 2012; the second period started on 1st may 2013 and end on 31 may 2013. The results showed a good agreement in term of qualitatively and quantitatively with the real measurement data, which gives this high-resolution model a chance to simulate the phenomenon and the hydrodynamic interaction between physical and hydrological conditions of the Shatt al-Arab river in Basra.

Keywords: Water resources Hydrodynamics, Mathematical Model, Simulation,

I. Introduction

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 30.5⁰N, 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 [1]. 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 [2-5]. Khalaf [6], developed a mathematical model of the selected items under the name of FESTS-VP to represent the flow range in the Shatt al-Arab. Mahmoud etal [7], they used Mike11 routine to simulate the hydrodynamics behavior of the northern part of the Shatt al-Arab. Al-Fartusi etal [1] Construct numerical modeling to stimulate the amount of fresh water inlet and discharge from Shatt al-Arab River in Basra city 30.50 N south of Iraq. Most of the mathematical model used so far based on the numerical solution of the Saint-Venant equations [8]. This equation is almost always used to model the different types of flow through the rivers see for example [9-16]. The goal of the present study is to reach out high accuracy in developing the Mathematical model by taking in to account the impact of weather in the calculation and to provide physical and hydrological conditions of the mathematical model for the numerical simulation which match to the reality. The result shows a good agreement between our mathematical model and the local measurement data.

II. Theory

Water is incompressible, which means that their densities are constant for a wide range of flows. This is a reasonable assumption except for certain extreme situations such as the cases where the fluid is under profound Incompressible Newtonian Fluid pressures. Since the density of river's water is constant, the continuity equation for this type of flow can be consider as incompressible flows which simplified as:

$$\frac{\partial u_x}{\partial x} + \frac{\partial u_y}{\partial y} + \frac{\partial u_z}{\partial z} = 0$$

Where u_x , u_y , u_z are the velocities along x, y, z direction. And the momentum equations can be simplified as:

$$\begin{aligned} \rho \left(\frac{\partial u_x}{\partial t} + u_x \frac{\partial u_x}{\partial x} + u_y \frac{\partial u_x}{\partial y} + u_z \frac{\partial u_x}{\partial z} \right) &= -\frac{\partial P}{\partial x} + \rho g_x + \mu \left(\frac{\partial^2 u_x}{\partial x^2} + \frac{\partial^2 u_x}{\partial y^2} + \frac{\partial^2 u_x}{\partial z^2} \right) \\ \rho \left(\frac{\partial u_y}{\partial t} + u_x \frac{\partial u_y}{\partial x} + u_y \frac{\partial u_y}{\partial y} + u_z \frac{\partial u_y}{\partial z} \right) &= -\frac{\partial P}{\partial y} + \rho g_y + \mu \left(\frac{\partial^2 u_y}{\partial x^2} + \frac{\partial^2 u_y}{\partial y^2} + \frac{\partial^2 u_y}{\partial z^2} \right) \\ \rho \left(\frac{\partial u_z}{\partial t} + u_x \frac{\partial u_z}{\partial x} + u_y \frac{\partial u_z}{\partial y} + u_z \frac{\partial u_z}{\partial z} \right) &= -\frac{\partial P}{\partial z} + \rho g_z + \mu \left(\frac{\partial^2 u_z}{\partial x^2} + \frac{\partial^2 u_z}{\partial y^2} + \frac{\partial^2 u_z}{\partial z^2} \right) \end{aligned}$$

Where, ρ , P , g , μ , are the density, pressure, acceleration of gravity, and viscosity respectively. The flow of water through the river is a distributed process since the flow rate; velocity and depth vary spatially throughout the river. Estimates of flow rate or water level at certain locations in the river system may be obtained using the above set of equations that define the conservation of mass and momentum along this river. This model is based on the above partial differential equations that allow the flow rate and water level to be computed as a function of space and time. 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]:

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

In order to get realistic and more accurate model, the climatic characteristics are included such as wind (coefficient of friction of the wind) as well as the water temperature. A clear understanding and quantitative description of wind effects on river flow are still outstanding. The generation and growth of wind waves are difficult matters even on standing water (for a discussion see Ch. 12 in [15]). They are further complicated on a river by the flow of the water and by the presence of the banks and the bed. Therefore, this study shall be concerned only with the mean properties of the flow in an open channel with wind blowing parallel to the water surface and in the direction of channel flow. The wind shear stress can be written as:

$$\tau_w = c_w \rho_a v_{10}^2$$

Where, c_w , ρ_a , v_{10} , are the wind fraction factor, air density, and velocity above 10m of the water surface.

I. Result and Discussion

The total lengths of the study area is 240 km, the mesh used in the Mike11 routine is assumed to be $\Delta x = 500\text{m}$ in distance step, and $\Delta t = 60\text{sec}$ in time step. To measured the amount of water discharge and calculate the water current in the case of high and low tides for a complete circulation of its range (13-hour) per day we uses the ADCP device (Acoustic Doppler Current Profiler). The measurement is done by the way of the section where the device fixed on a boat and then moves the boat at a constant speed from one of the banks the river to the other side in a straight line and during the process of scanning the cross-section of the river device sends sound waves through the water column to the reception after reflection according to the Doppler effect which allow us to calculate velocities, direction and the discharge as shown in Figure (1). The measurement data are collected for two periods, the first period started on 1st oct. 2012 and end on 31 oct. 2012; the second period

started on 1st may 2013 and end on 31 may 2013. The study area affected by two main type of wind, First: north westerly wind, which are clear during the cold seasons. Figure (2a) shows the values of velocity and direction of the wind during the period from 1 to 31 October 2012 where we see that the northern winds are common and the maximum values registered of the wind speed is (9 m/s), Second: south easterly moisture winds which are common through the warm seasons, and come in second place in terms of redundancy and speed. Figure (2b) shows the values of speed and direction of the wind during the period from 1 to 31 may 2013. Four different station are chosen for the simulation purpose, the location of these station and the date are chosen to compare our simulation with the true field measurement. These are recorded in table below, and the results of these comparisons are presented in figure (3). One can conclude that our simulations are all most give us a good picture, where we note that there is a match quantitative and qualitative with the field measurement data.

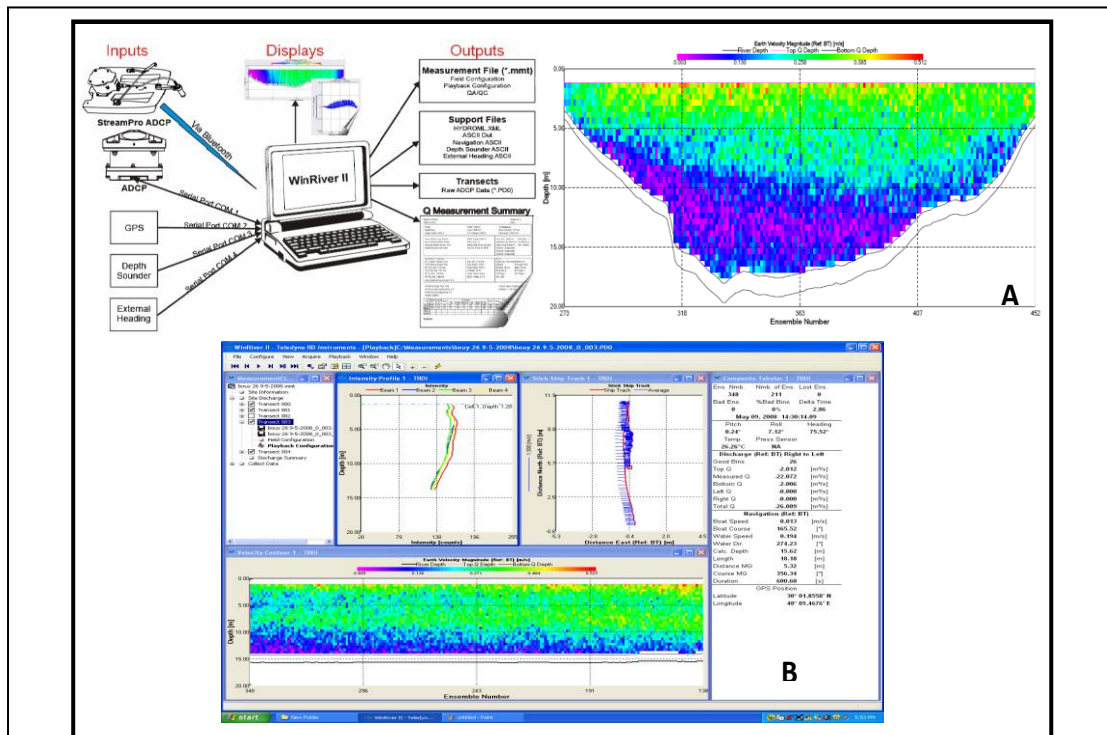
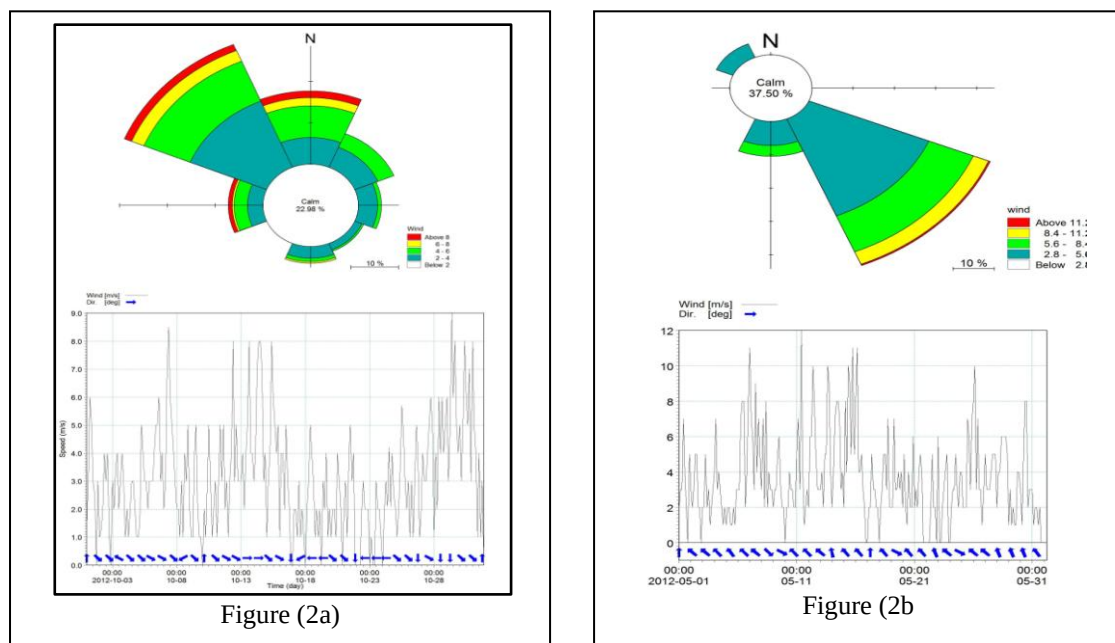
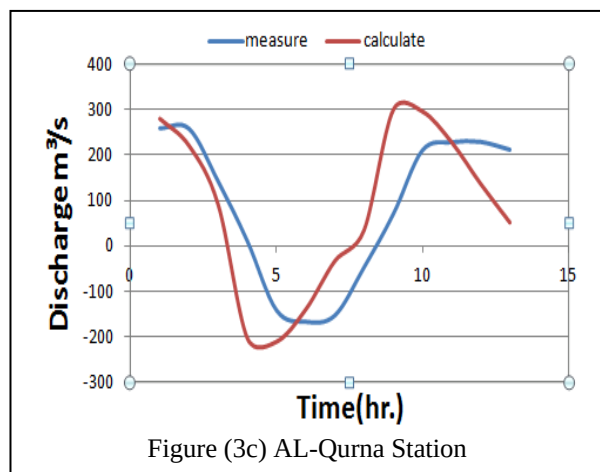
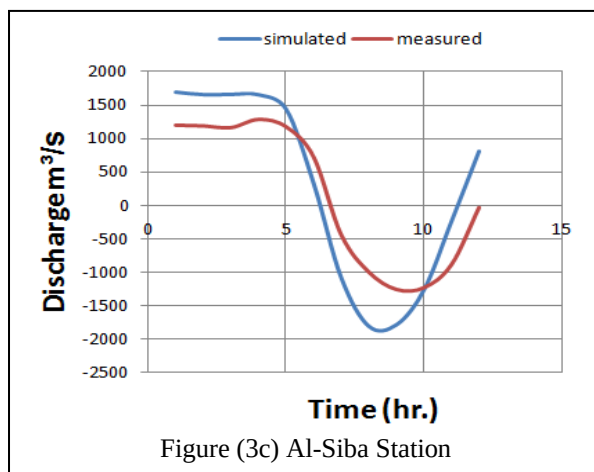
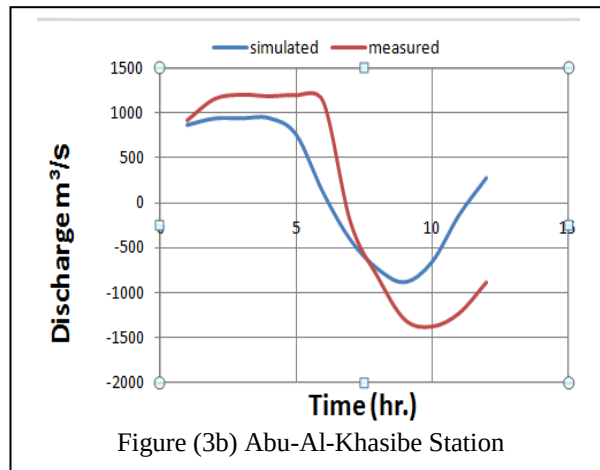
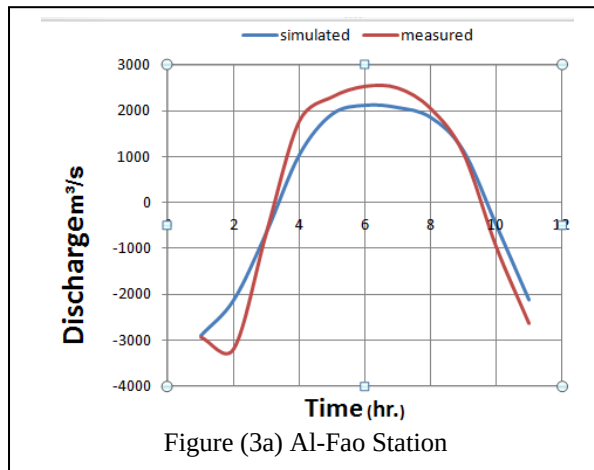


Figure (1) The measurement of the water current by ADCP device. (A) Represent the shape of the measure cross section. (B) Measurement of the Speed, direction, and the discharge.



Stations	Location		Date
	Latitude	Longitude	
AL-Fao	29° 58'	48° 28'	15 October 2012
Abu Al-Khasibe	48° 00'	30° 27'	17 October 2012
Al-Siba	48°15'	30°20'	18 October 2012
AL-Qurna	47°28'	30°56'	28 may 2013

Location of the different stations and the date of collection data for simulation.



VI. References

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