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REVIEWARTICLE

ENVIRONMENTAL HYDRODYNAMICS MITIGATION AND WATER QUALITY MODELLING, CASE STUDY EL- BURULLUS LAKE IN EGYPT- USING SMS 12.1

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ABSTRACT

The Northern coastal lakes in the Nile Delta of Egypt which have an ecosystem of distinctive nature is facing several problems which threaten, There are two main problems facing the coastal region of the delta, The first one is the erosion due to dynamic effects and reduction in sediment transport, the northern lakes connected to the Mediterranean Sea severely suffer from pollution due to dumping wastewater from agricultural, municipal as well as industrial origin into the lake. Hydrodynamic modeling is an essential tool to simulate the combined effect of these physical factors. Modeling the circulation pattern inside the lake is considered an essential tool in order to investigate the Lake water balance.

INTRODUCTION

Burullus Lake is the second largest of the Egyptian northern lakes along the Mediterranean coast. It is located in the central part of the northern shoreline of the Nile Delta between longitudes $30^0 30'–31^0 10'$ E and latitudes $31^0 35'–31^0 21'$ N as shown in Figure (1).Water depths vary from 0.4 m to 2.75 m, Where (i.e. shallow lake),the maximum water depth is recorded near EL-Boughaz outlet. The lake surface area is about 410 km2, of which 370 km2 is open water (1), The remaining area is islets, with 65 km coastline and 11km width. Eight drains discharge into Burullus Lake with a total discharge of 3904 million m^3/year including agricultural, industrial and domestic waste water, In addition to the fresh water from Brimbal Canal situated in the western part of the lake with total discharge 190 m^3/yr, which is representing 5% of water discharged into lake. Pollution inside the Lake is due to chemical pollution, which comes from the industry and this indicates an industrial growth in the region. The lake's high nutrient environment allows floating plants to grow extensively. In addition, Total suspended solids TSS values are very high, which means that the high pollution of organic and non-organic material from industrial and agriculture waste. Declining of salinity levels inside the lake is considered a major problem. Total percentage by weight of marine fish species such as Liza Ramada decreased from 16% in 1973 to less than 1.8 % in 2003 and fresh water fish such as Tilapia increased from about 81% to 98.2 % (3).

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The brackish lake salinity levels range from 2.1‰ in the west to 17.2‰ in the north, The main water quality problems in the Lake are the declining salinity level and deterioration of water quality, Salinity values were significantly high during 1973 comparing with 2002, Even the minimum salinity values in 1973 are higher than the maximum values in 2002 as reported before (2).In summary, all these lead to the necessity of establishment of a proper management system to control pollution inside the Lake. So the purpose of this study is to investigate the potential and effects of several factors, which could be applied for this purpose, a comprehensive environment for multi-dimensional hydrodynamic modeling was used. The Surface Water Modeling System (SMS) model was performed for hydrodynamics and water quality study. The above figure (1) shows the drains discharge into the lake were obtained from NWRI 2016.

MATERIALS AND METHODS

Data collection for simulation and calibration: The available data of the Bathymetry Lake are include hydrodynamic data like as (bed level elevations), meteorological (temperature), and geometrical (boundary lake coordinates), Water quality parameters data for many stations located in the lake as shown in figure (2), this datasets was used to create the bathymetry mesh model and in the calibration/validation process of hydrodynamic model, where The model also used to simulate the distributions of the salinity. The coupled-hydrodynamic-water quality models were utilized in assessing the mitigation scenarios aiming at enhancing the circulation patterns and controlling pollution inside the lake.

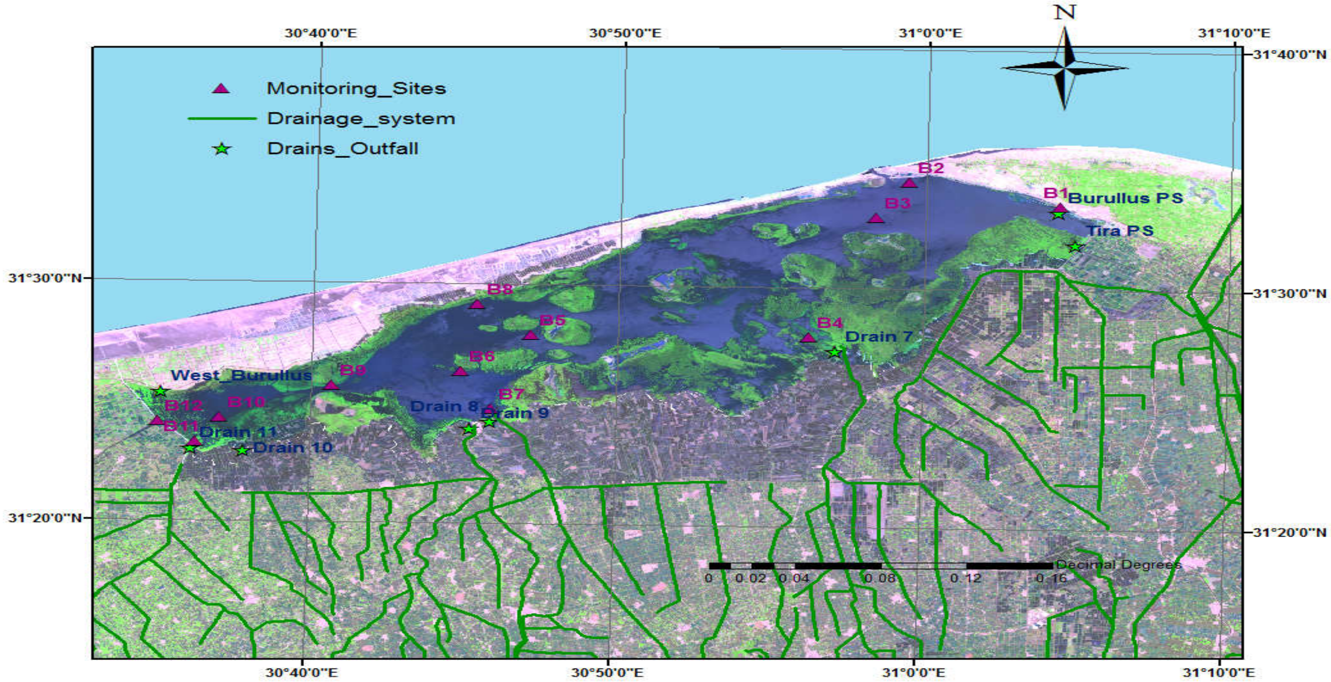

Figure1. Satellite Map of Lake Burullus

Figure 2. Lake El-Burullus map showing the water quality field measuring stations during 2014-2015

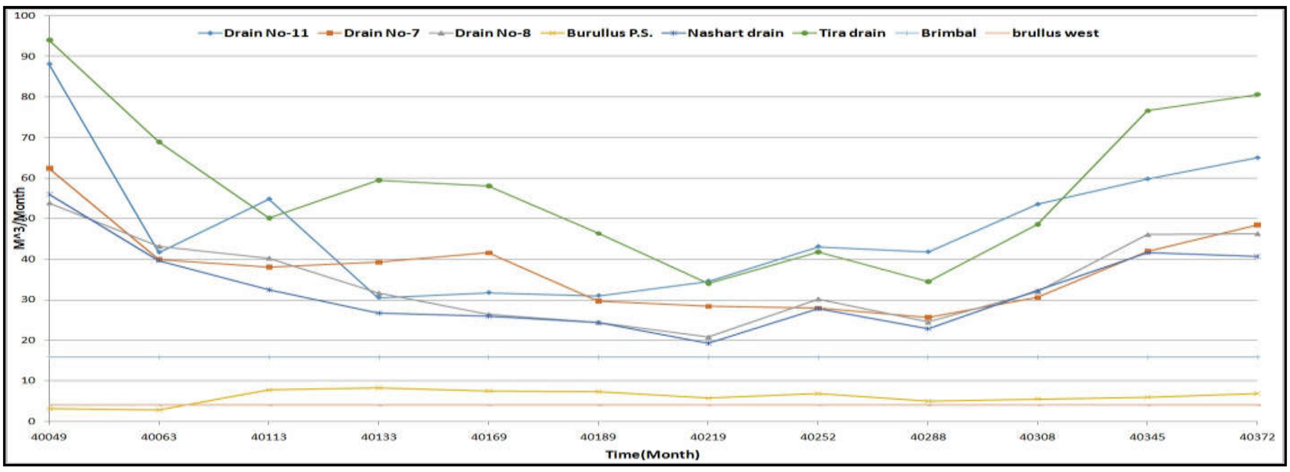

Figure 3. Lake El-Burullus map showing the water quality field measuring stations during 2009-2010

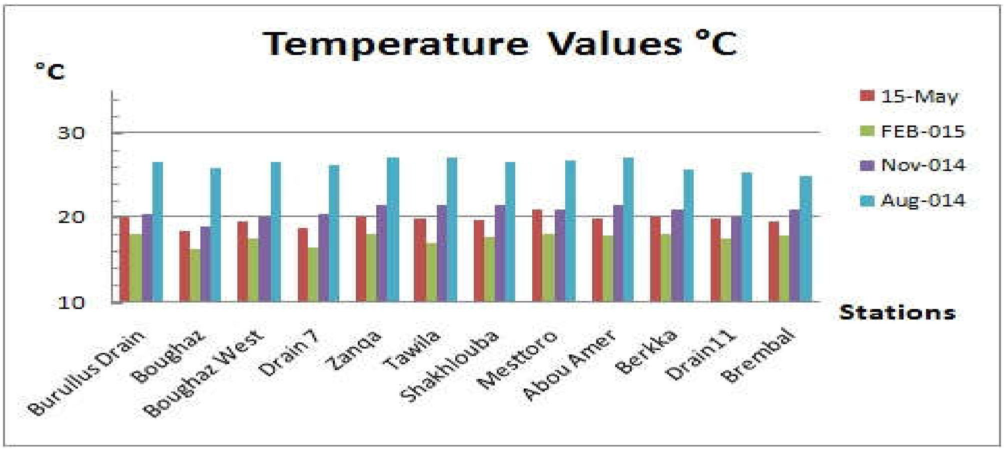

Figure 4. Stations Temperature inside lake El-Burullus for year 2014-2015

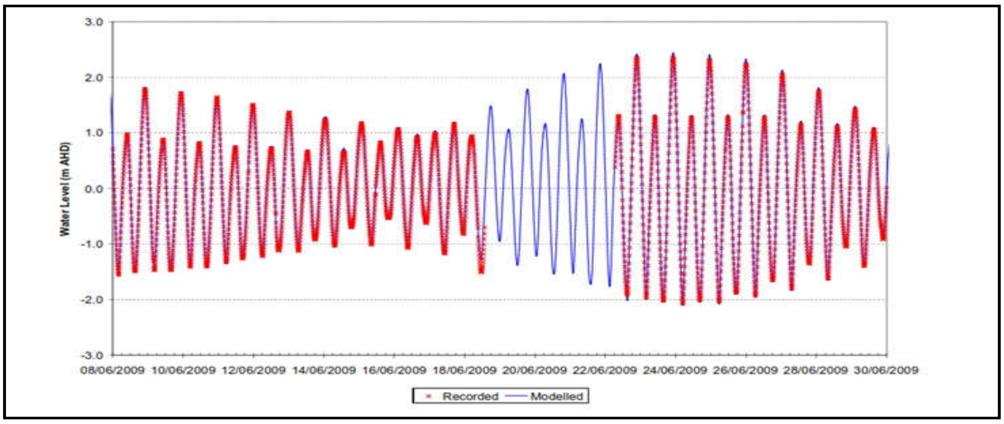

Figure 5. Neap and Spring Tides

Creation of model mesh

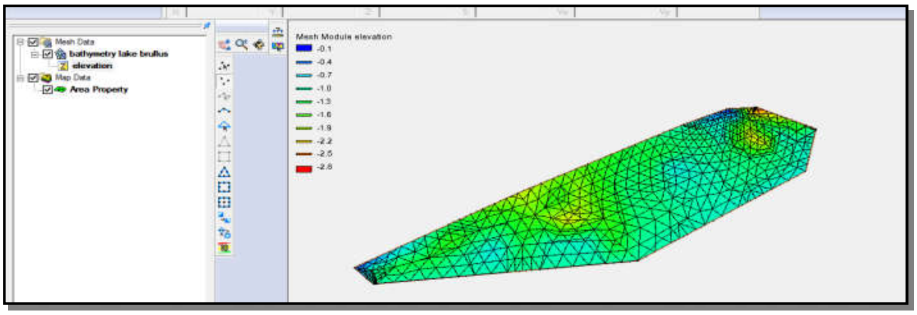

Figure 5. Bathymetry Mesh for Bed Elevations of Lake El-Burullus

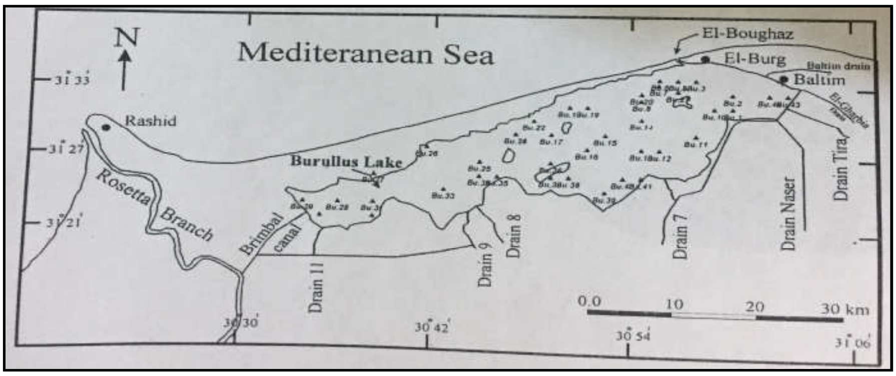

Figure 6. Water Depths Monitoring Stations (5)

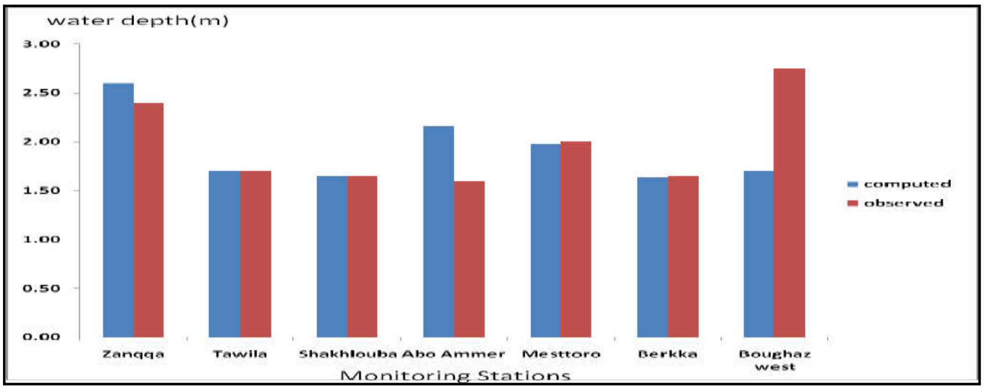

Figure 7. The measured and simulated water depth at monitoring station

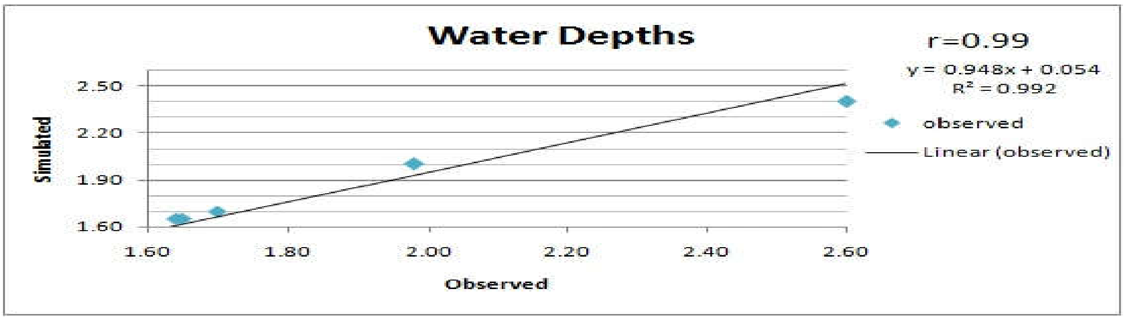

Figure 8. The correlation coefficient between the measured and simulated water depth at monitoring station

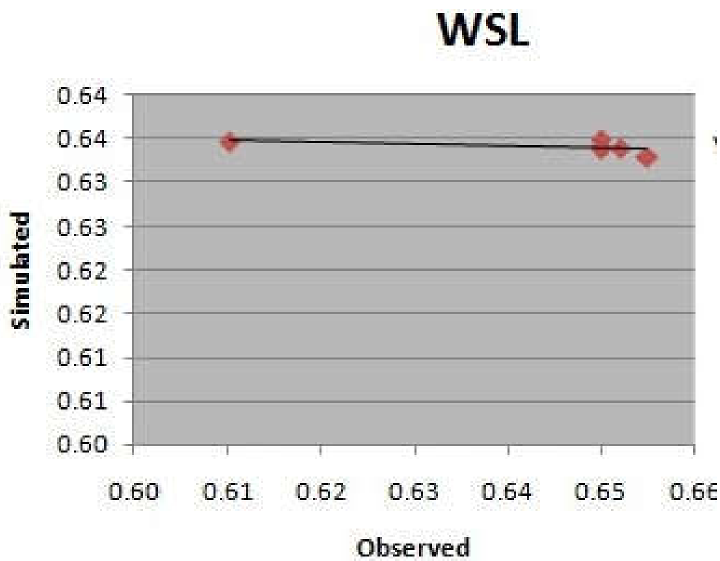

Figure (9) the correlation coefficient between the measured and simulated water sea levels at Monitoring station

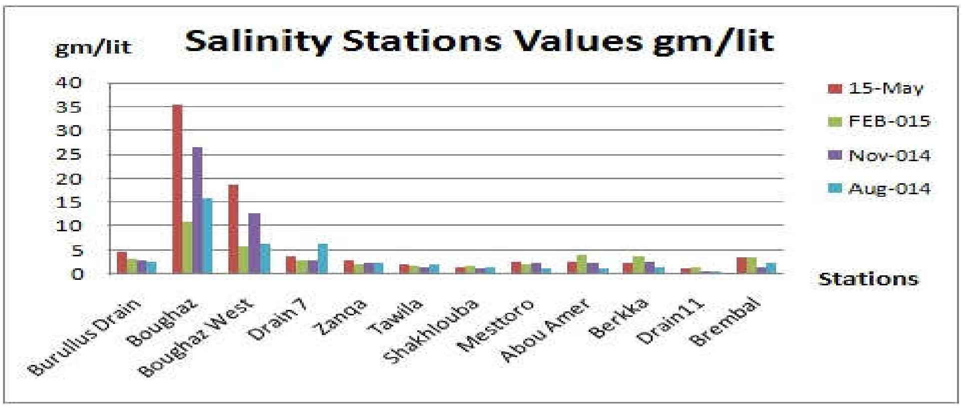

Figure 10. EL-Burullus lake water salinity (gm/lit) values at different stations during the four seasons for year (2014, 2015)

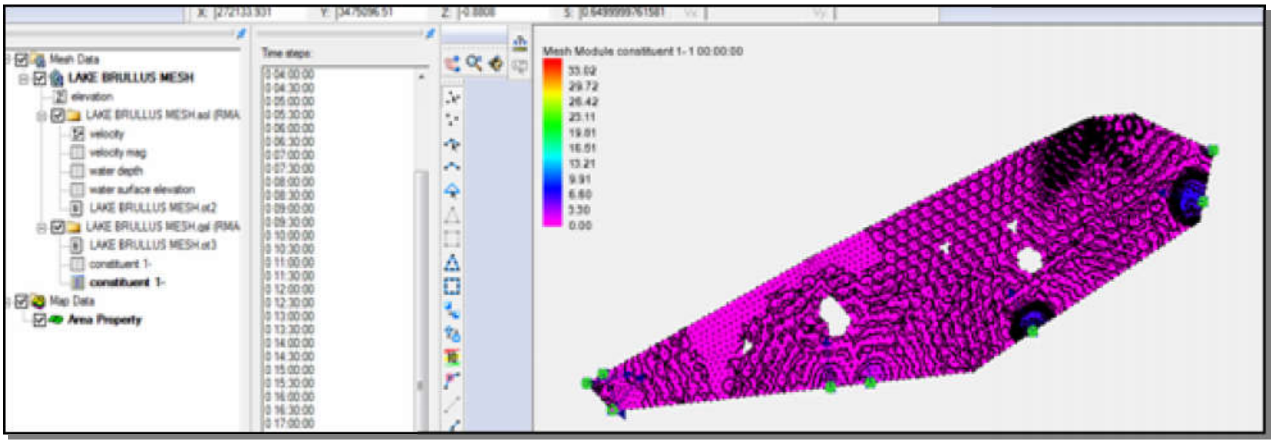

Figure 11. EL-Burullus lake water salinity intrusion (gm/lit) during autumn 2015, across El-Burullus lake high salinity indicated by dark color

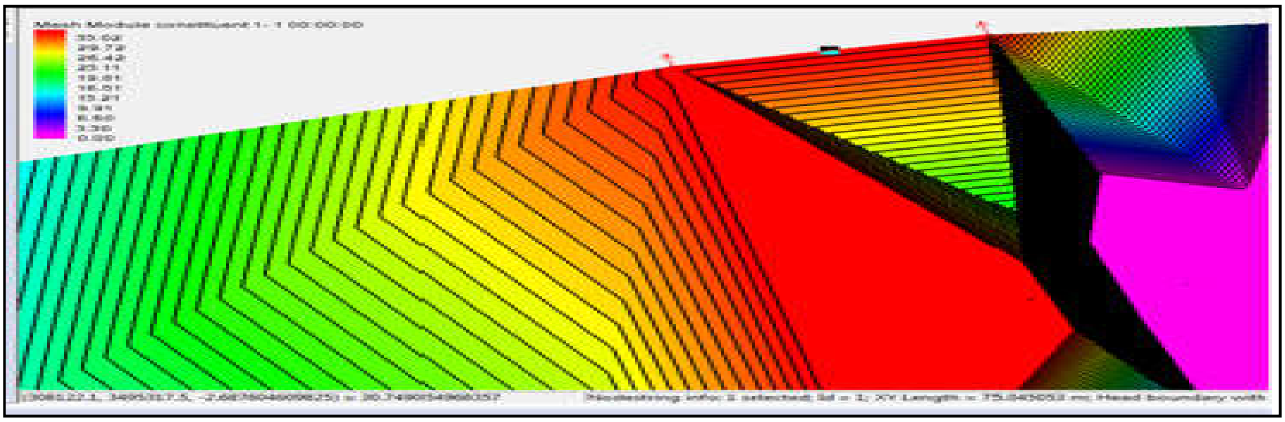

Figure (12) EL-Burullus Lake water salinity (gm/lit) during autumn 2015, around Boughaz outlet, high salinity indicated by red color

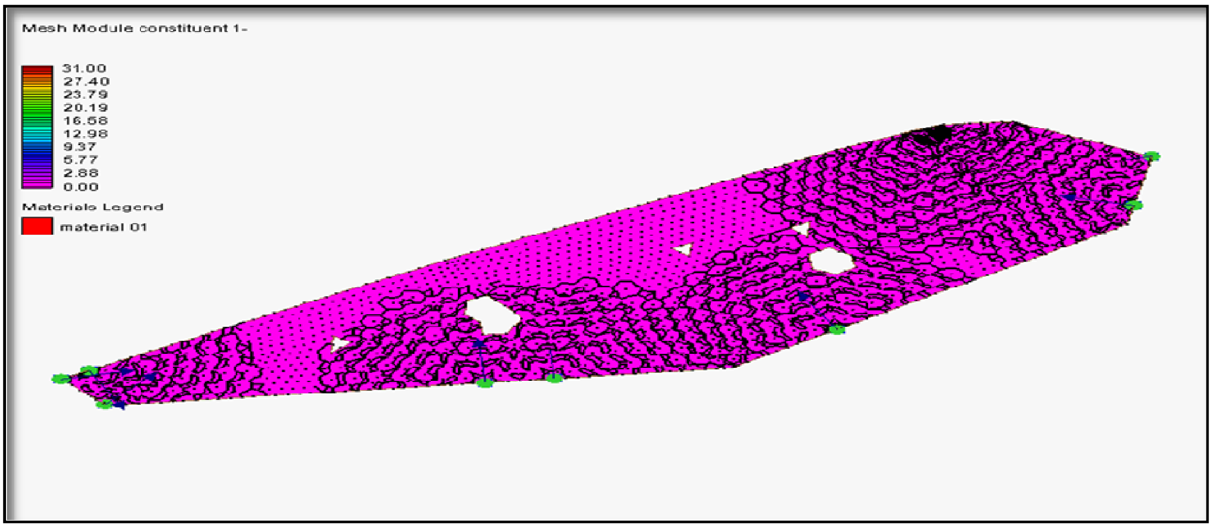

Figure (13b) EL-Burullus lake water salinity (gm/lit) around Boughaz outlet high salinity indicated by red color

Drains discharge, for the period ranged from 24/8/2009 to 24/7/2010 has been collected by Coastal Research Institute CoRI as shown in Figure. Types of Assessment tidal levels, velocities and flows.Contours interval for water depth, the deepest area is towards to EL-Boughaz indicated by blue colors as shown in Figure (5).The above figure shows the measured filed stations for water depths inside the lake, which will be used for validation the simulation results.

Hydrodynamic Model calibration and validation

The model was calibrated using the available monthly averaged discharges data, averaged water depths and monthly averaged salinity and temperature. The average discharge shows in Figure (3). Simulated water depth, velocities and average sea water surface in the lake is compared to the measured data where recoded before. (3), (4).

As shown in figure (7),(8) the comparison between the computed and observed values for water depth at known monitoring stations the comparison shows the minor difference between two value indicated to perfect relation with correlation factor equal0.99

As shown in figure (9) the computed and observed values for water sea levels at known monitoring stations the comparison shows that there is minor difference between them, which indicated that good relationship with correlation factor equal 0.99.

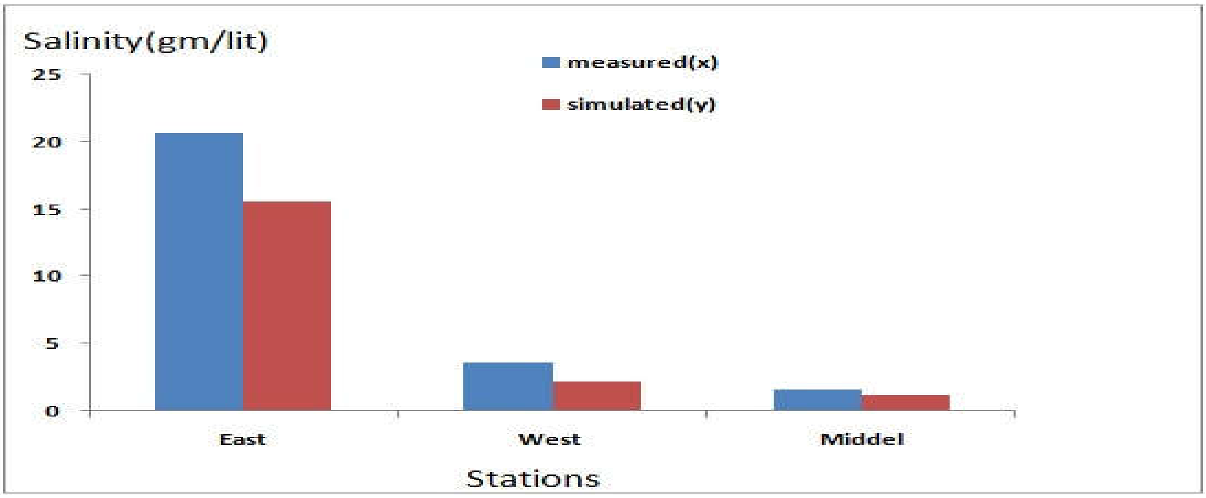

Figure (13c) the measured and simulated values at monitoring station

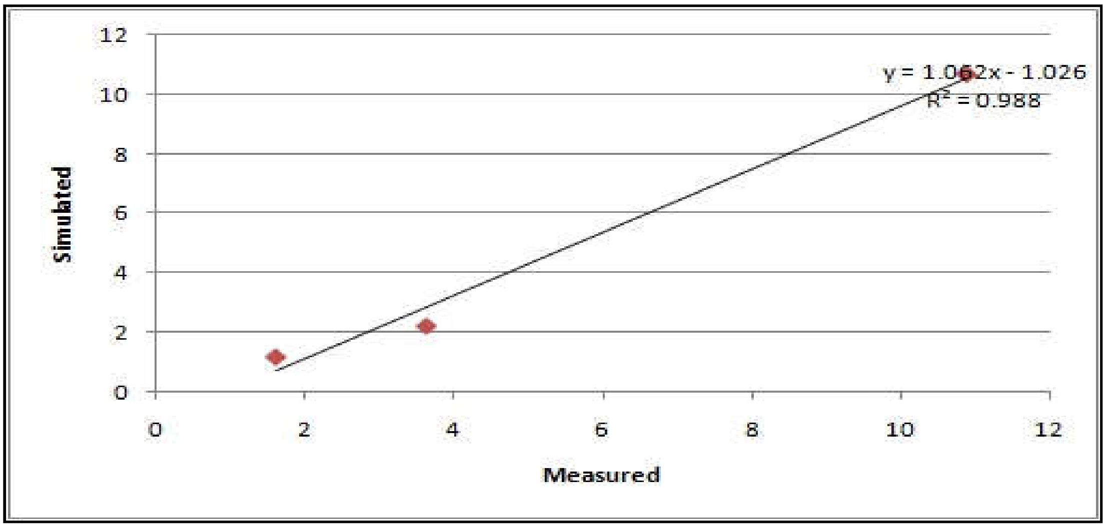

Figure (13d) the correlation coefficient between the measured and simulated at monitoring station

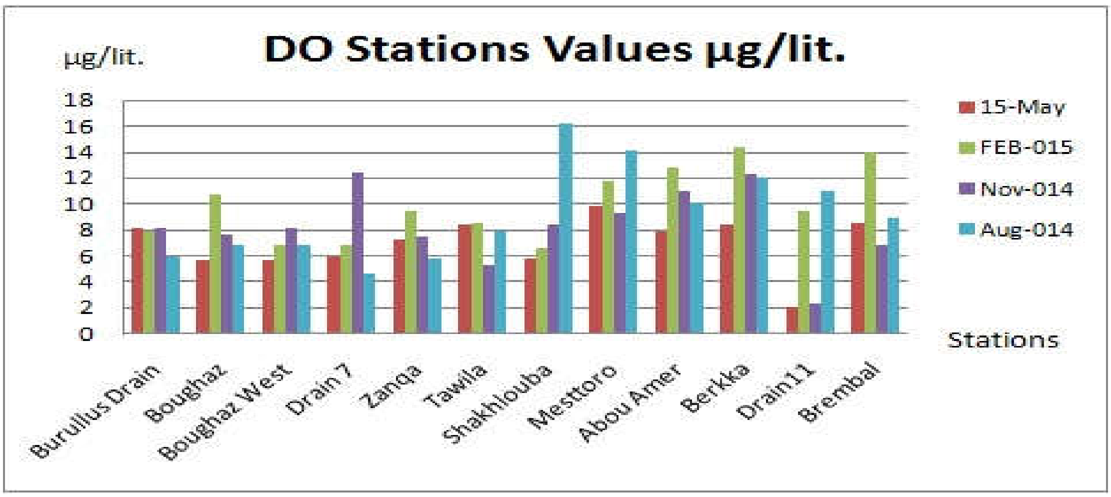

Figure (14) water parameter distribution (DO), (µg/l) at different stations during the four seasons for year (2014, 2015) across EL-Burullus lake

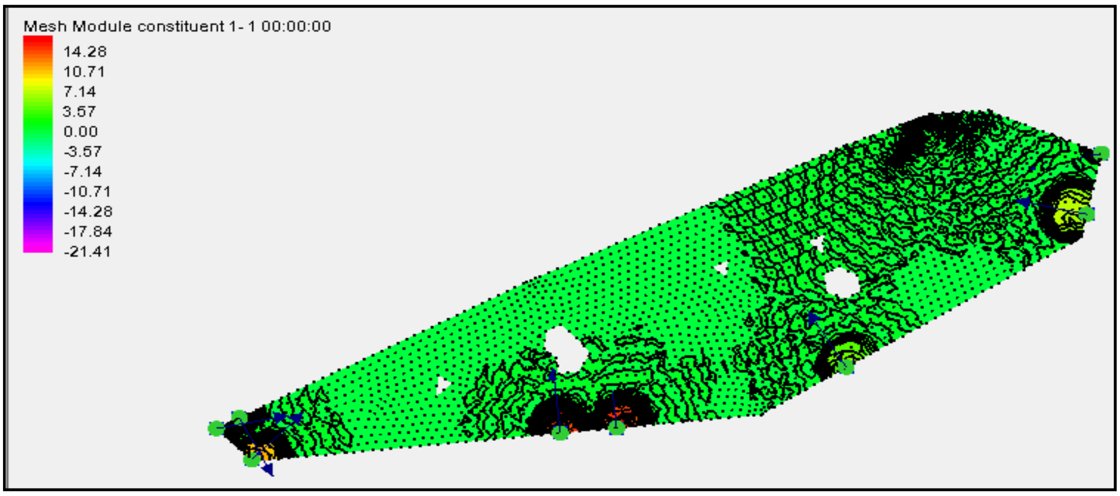

Figure (15) EL-Burullus lake water DO (mg/l) during August 2014, across high DO indicated by dark color, at Dx=0.5 m^2/s, Dy=0.5 m^2/s

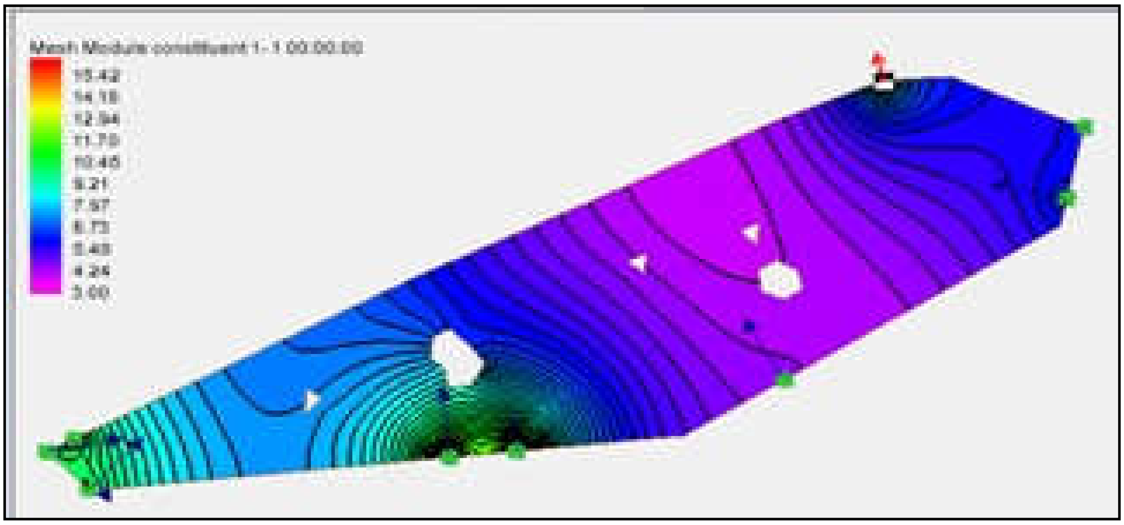

Figure (16a) EL-Burullus lake water DO (µgm/lit) during August 2014

From the output curves and results the model was calibrated manually using monthly average discharge and daily water levels, water bed elevations, Wind force and tide wave are used in the simulation also, Results give a good picture of hydrodynamic regime of the lake that can be used later with other applications (e.g. water quality). (4)

Water Quality Simulation

The model will be calibrate salinity and dissolved oxygen parameters and validated it with field measured values at marked stations as shown in the figure (2). Salinity distribution will be study in autumn and winter season.

Calibration For Salinity Parameter

The salinity (TDS) values inside the lake varied from 1.07 gm/lit to 35.46 gm/lit, during Autumn 2015, as shown in figure (10) it becomes high near EL-Boughaz inlet cause the influence of the Mediterranean Sea water entering the lake by action of tidal wave, also it is noted that the low value in the north west side near Messtoro station monitoring due to the existing of floating weeds.

The measured and simulated salinity has been monitoring at five stations that covering Lake EL-Burullus,(Berkka, Elzanqa ,Abu amer,mestoro,EL-Tawila,Burullus west),the station berkka,burullus west and Eltawila,shows very good agreement with the measured salinity, but there are many variations in Messtoro station record, where EL-Burulus west salinity record value 20.02 gm/lit in simulation instead of 18.62 gm/lit in filed measured with correction coefficient factor equal 0.92,Regarding to middle part in the lake, (Elzanqa,Eltawila) stations the simulation shows the salinity values ranged between (0 to 1e-6 gm/lit).

Validation For Salinity Parameter

Using the measured data sets, and simulated values were adopted by using the correlation equation set before to evaluate numerical simulation precision. The correlation value R by using the above equation is set to 0.98 which mean very strong relationship. Salinity is not subject to water quality processes. Salinity level can isolate the effect of transport which leads to help to distinguish between the effect of transport and processes for other substances

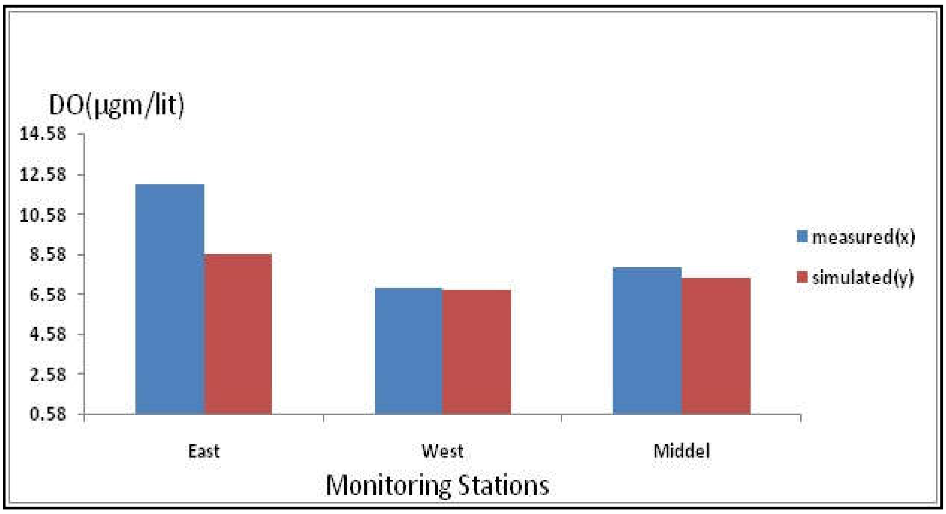

Figure (16b) the measured and simulated values at monitoring station

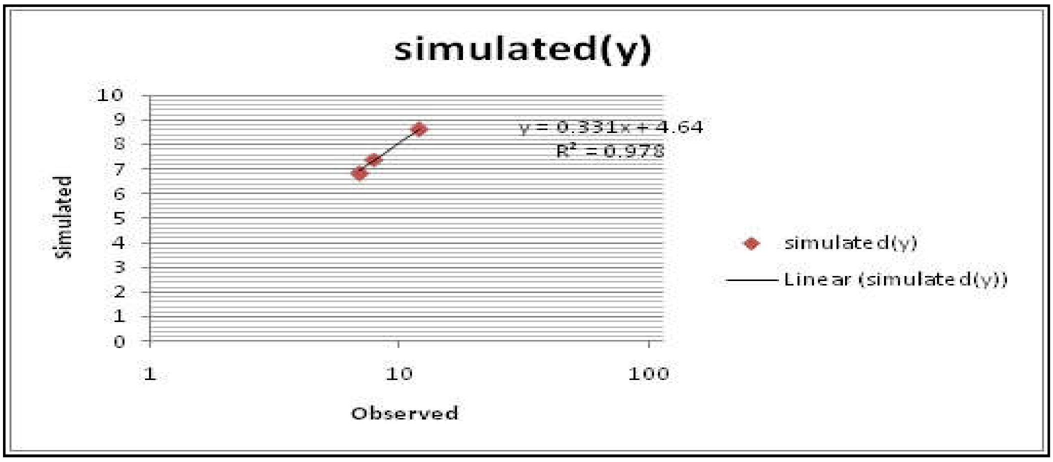

Figure (16c) the correlation coefficient between the measured and simulated at monitoring station

Calibration For Do Parameter

The second calibrated parameter is (DO) Adequate concentrations of dissolved oxygen in a lake are critical to the health of its aquatic biota. The amount of oxygen that can be held by the water depends on the water temperature, among other variables. (6), the average Dissolved oxygen (DO), measured by National Water Research Center, (NWRC) is 16.17 µg/l**,** in summer season the high amount of DO is attributed to high photosynthesis by water plants that occupy 25% of the total area of the Burullus Lake. (7) The figure (14), show (DO) water parameter distribution (µg/l) at different stations during the four seasons for year (2014, 2015) for EL-Burullus Lake. The highest value is 16.17µ g/l, at El-shakloba station in August 2014, and the next one measured at EL-Berkka Febrauary 2015 in the west region followed by mesttoro station in the northern area of the lake. The figure (16), shows (DO) water parameter distribution (µg/lit.) at Brimbal canal, darin-11 and brullus west during the winter for year (2015), high concentration indicated by red color near drains inlet. By Using the measured data sets, and simulated values were adopted by using the correlation equation set before to evaluate numerical simulation precision, the correlation value R by using the previous equation is set to 0.978 which also mean very strong relationship

Summary

After the calibration and validation of water quality models for various parameters using SMS software, and after discuss the results of the water quality models including the parameters used in the calibration and statistical evaluation of the results and the effect of the deviation coefficient Dx, Dy, which has force on the model, Also wind force and water temperature has been taking in this calibration. The measured and simulated salinity had a correlation coefficient of 0.99 and a correlation coefficient of DO was 0.97.The result shows that this simulation has very good relationship between measured and computed values, Hydrodynamic results were successfully used as inputs to a coupled water quality model. Models provide reasonable results for water quality simulation so we can build a prediction scenario on this model (SMS 12.1)

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