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Improvement of the Hydrodynamic Behavior and Water Quality Assessment of Al-Chibayish Marshes, Iraq

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ABSTRACT

Al-Chibayish Marsh (CM) is considered as the major part of Central Marshes area of this marsh is 1050 Km^2. The water quality of these marshes is suffering from salt accumulation due to intensive dam construction, limited supply of water from sources, climate change impacts, and the absence of outlet flow from these marshes, specifically at low flow periods. So, the current research aims to assess and improve these marshes' hydraulic behavior and water quality and define the best location for outlet drains. Field measurements and laboratory tests were conducted for two periods (November 2020 and February 2021) to define the (TDS) concentrations at nine different locations. Samples were also examined for water's physical and chemical properties as pH, electrical conductivity, water temperature, dissolved oxygen, and turbidity. Simultaneously with the sampling process, the water depths were measured at 50 different locations within the marshes. Moreover, the observations of water quality parameters were analyzed for the previous ten years (2010-2020). Hydrodynamic and water quality simulations were conducted using (SMS-RMA2 and RMA4) software to specify the water depths and velocity variations and define the salt content distribution. The obtained results illustrated 4sediment and TDS and in the Central Marshes area in general and CM in specific. As well, numerical results showed that the use of these outlets would significantly improve water quality. The current outlets do not work, and they link the Euphrates River to the Chabayish Marsh.

Keywords, Al-Chibayish Marshes, SMS, GIS, Water QualitySimulation.

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تحسين السلوك الهيدروديناميكي وتقييم نوعية المياه في اهوار الجبايش، العراق

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الخلاصة

تمثل اهوار الجبايش المنطقة الرئيسية للاهوار الوسطى ، وتعاني نوعية المياه في هذه الأهوار من تراكم الأملاح نتيجة البناء المكثف للسدود، ومحدودية إمدادات المياه من المصادر، آثار تغير المناخ بالإضافة إلى عدم وجود منافذ تدفق لمياه هذه الأهوار على وجه التحديد في فترات التدفق المنخفض. لذلك ، يهدف البحث الحالي إلى تقييم وتحسين السلوك الهيدروليكي وجودة المياه لهذه الأهوار وتحديد أفضل مواقع منافذ المصارف. أجريت القياسات الميدانية والاختبارات المعملية لفترتين (نوفمبر 2020 ، و فبراير 2021) لقياس إجمالي تراكيز المواد الصلبة الذائبة **(TDS)** في تسعة مواقع مختلفة. حيث تم فحص العينات للخصائص الفيزيائية والكيميائية للماء مثل الأس الهيدروجيني والتوصيل الكهربائي ودرجة حرارة الماء والأكسجين المذاب والعكارة. بالتزامن مع عملية أخذ العينات ، تم قياس أعماق المياه في 50 موقعًا مختلفًا داخل الأهوار. علاوة على ذلك ، تم تحليل بيانات عوامل جودة المياه للسنوات العشرة الماضية (2020-2010)**.**

أجريت عمليات محاكاة الهيدروديناميكية وجودة المياه باستخدام برنامج لمعرفة اعماق المياه وتغيرات السرعة ولتحديد توزيع محتوى الملح. أظهرت النتائج التي تم الحصول عليها الحاجة إلى منفذ واحد أو أكثر لتصريف مياه الأهوار ولتوزيع جيد للرواسب والمواد الصلبة الذائبة وفي منطقة الأهوار الوسطى بشكل عام وفي هور الجبايش بشكل خاص. بالإضافة إلى ذلك ، أظهرت النتائج العددية أن استخدام هذه المنافذ سيحسن بشكل كبير جودة المياه**.**

كلمات الرئيسية: اهوار الجبايش ، **SMS** ، نظم المعلومات الجغرافية ، محاكاة جودة المياه.

1. INTRODUCTION

Four primary factors are important to indeterminate the water quality of southern marshes. The first, increase the rate of evaporation, stagnant water, or a slow flow, Coverage of aquatic macrophytes as a percent, or the density and volume of pollutants/sewage carried by the Tigris waterways Euphrates **(Hassan, 2010)**.

The majority of previous research focused on physical and chemical factors, and they revealed that Al-Chibayish marshes' water quality had deteriorated. It was found that the water in the marshes is unfit for human consumption and insufficient for agricultural facilities and other activities **(Al-Saboonchi, 2011)**. The results of water sampling from three sites in CM between December 2011 and February 2012. Also, it showed that it is of poor quality and unsafe for human consumption. Agriculture and other commercial water uses are less suitable **(Mohammed, 2017)**. The investigations in 2015 clarified that the levels of total salts varied in CM between good and allowed for use, but only for animal use, which is very high salinity water and not suitable for irrigation, with a high content of salts. Except for crops that bear a high degree of salinity **(Al-Ansari, 2020)**. The water quality of CM was (fairly good) according to the NSF-WQI and other Iraqi and WHO standards in 2016 **(Mohammed, and Rajab, 2017)**. The Canadian Water Quality Index was used in the analysis. Water samples were taken from six sites per month from August 2018 to July 2019. The results showed that all stations' average total dissolved solids (TDS) were classified as the second category Mesotrophy **(Farhood, 2016)**. The hydrological changes in the southern Iraqi marshes, including Central Marshes, were studied. Examining the water quality features revealed that the marshes' qualities had deteriorated due to a shortage of water, resulting in high total dissolved salt levels **(Al-Asadi, and Al-Hejuje, 2019)**.

Changing climate is having a significant impact on water resource estimates and quality and quantity in the future **(Noma, and Mohammed, 2017)**. The NDVI analysis and photo classification showed the disappearance of plants and water bodies in Marshes, as large swaths of agricultural lands and natural vegetation vanished, leaving barren landscapes in their place **(Abbas, et al., 2016)**. The satellite remote sensing was used, revealed a decrease in plant and water coverage, increasing in barren regions **(Hashim, et al., 2019)**. The other part of the studies is the hydrological investigation: one of the hydrological investigations carried out with the help of various software is HEC-RAS and SMS-RMA2. According to the results, the maximum monthly input discharge required for full restoration is 483 m3/sec, with a steady discharge of 134 m3/sec **(CRIM, 2006)**. The Landsat 8 satellite images were used. According to the study, the year 2019 represents a turning point in the actions of the marshes, which had been suffering from a drought, as their area rose by nearly 140 percent in comparison to 2018 and 60% in comparison to 2017 **(Reyadh, et al., 2018)**.

This research aims to study water quality in the CM with different physical and chemical properties and create a quantitative, quantitative mathematical model for water quality based on TDS as an indicator. Also, improve the water quality in the CM by suggesting multiple alternatives for marsh water outputs to reduce the accumulation of TDS in the marsh due to the absence of outlets.

The description of the study area, the physical and chemical parameters, fieldwork, laboratory tests, and numerical simulation models will be illustrated in the following paragraphs.

2. MATERIALS AND METHODS

2.1. Site Description

Central Marshes' depression is the largest in the region **Fig. 1**, which covered an area of around 3000 km2 in the 1970s **(Talal, 2013)**. Now, the total possible inundated area is 2100 km^2. CM occupies an area is 1050 Km^2 of them. This area is located between 675000 and 712386 m Easting and 3483000 and 3425000 m Northing in zone 38 N, UTM-WGS84. The Tigris River tributaries (Al- Bittera, Al- Areedh, and Al-Majer Al- Kabeer Rivers) are located on the north side of Central Marshes in Amara Governorate. The Euphrates River is located on the south side of this area, between the Souq-Al-Sheouk and Al-Qurna districts. From the west, a road connects the villages of Al- Salam and Al-Islah, the Missan (al-izz) river located on the east side.

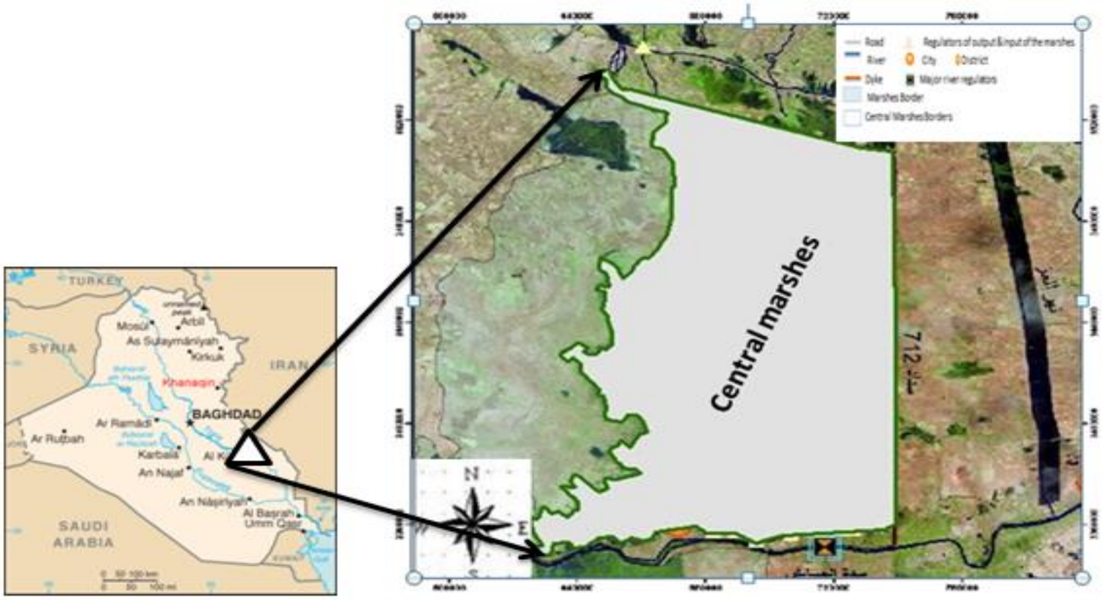

Figure 1. The Central Marshes' layout.

2.1.1. Topography of Central Marshes

The topography of Central Marshes was constructed using the available DEM, which was attended by CRIM in 2006, as a basis. It was corrected based on surveys made by CRIMW for various years and field measurements, as shown in **Fig. 2.**

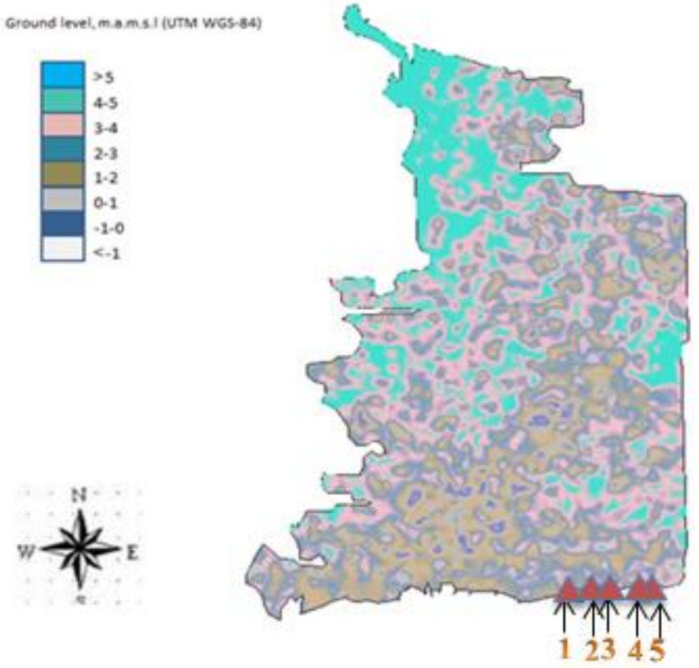

Figure 2. The study area's topography (CM).

2.1.2. Area and storage elevation curves

The area and storage elevation curves for Central Marshes were derived using the DEM of the marsh **(Marghany, et al., 2016)**, as shown in **Fig 3.**

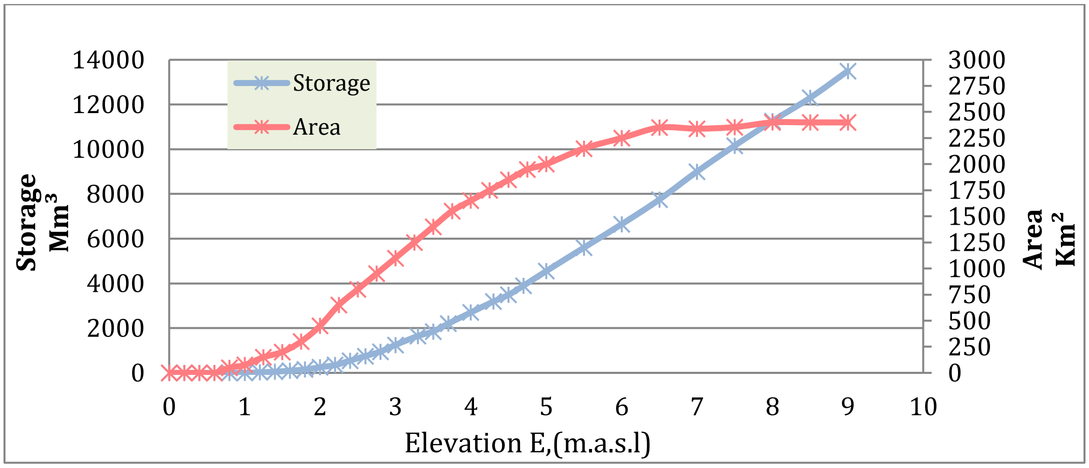

Figure 3. Curves of area-elevation and storage-elevation in the Central Marshes **(Marghany, et al., 2016)**.

2.1.3. Discharge of feeders

A complete set of monthly discharge measurements for the main feeders of the marsh was carried out by CRIMW, as presented in **Table 1**. The water of Central Marshes is the product of the Tigris and Euphrates combining **(Tahira, et al., 2008).** Previously (until the 1970s), the location relied mainly on water from the Tigris River, but today heavily relies on water from the Euphrates River (Fazaa, et al., 2018). To improve water levels and feed Central Marshes, a weir was built on the main channel of the Euphrates River in 2010 **(Shayea, and Al Thamiry, 2020).**

Table 1. Monthly discharges of the feeders based on CRIM data.

years	Mean monthly discharges from Euphrates and Tigris Rivers, m³/s											
2011	9.1	12.7	7.2	9.6	10.9	9.9	17.6	19.1	16.8	16.8	6.3	16.5
2012	14.2	15.3	9.3	16.8	13.2	11.6	19.5	15.25	19.9	20.3	7.9	14.6
2013	70.1	50.1	50.9	38.2	71.3	39.2	45.6	40.53	49.7	57.3	60.3	59.9
2014	92	58.8	65.7	76.8	64.1	49.4	49.9	43.49	36.5	36.6	24.8	28.8
2015	29.4	37.9	23.3	36.4	43.2	27.8	12.4	13.83	26.4	22.8	33.8	26.9
2016	45.3	40.5	54.4	68.9	62.1	46.9	47.9	42.17	40.1	51.5	25.4	40
2017	52.8	34.4	39.9	62.8	78.5	63.1	47.2	37.77	38.8	30.9	16.9	11.1
2018	23.9	31.2	36.8	42.8	28.9	19.0	14.5	19.43	16.6	22.9	58.2	103.2
2019	91.9	149.8	105.5	244.4	221.1	80.8	76.9	92.39	101.2	111.8	80.6	154.2
2020	77.6	85.5	105.6	71.5	48.1	56	71	59	70	77	48	76

2.1.4. Evapo-transpiration

With a monthly total of 274.70 mm and an average daily value of 8.86 mm, the Central Marshes are in a high-evapo-transpiration area. According to **Fig. 5,** it was 1.38 mm in January and 8.86 mm in August.

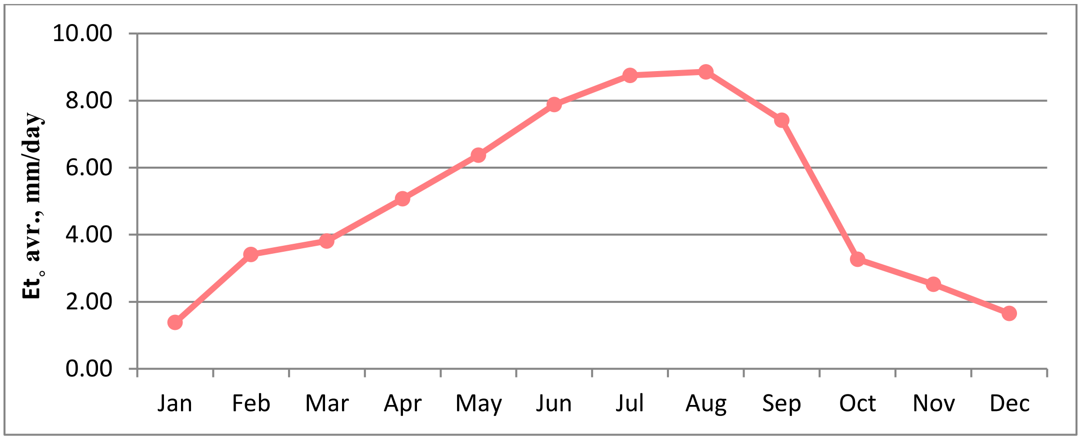

Figure 5. Evaporation in the Central Marshes zone.

2.2. The Physical And Chemical Parameters

The most widely accepted definition of water quality is the physical, chemical, and biological characteristics of water **(Alley, 2007)**. The most important characteristics are:
Water temperature is one of the most important physical factors that influence the ecosystem of water bodies. Temperature affects viscosity, palatability, smells, solubility, as well as chemical reactions **(APH, 2005)**. The electrical conductivity (EC) of water is a numerical value that indicates how well water conducts electrical current **(Tchobanoglous, et al., 2003)**. This value is influenced by the concentration and equation of dissolved ions in the water, as well as temperature. The EC value of water has a strong connection to salinity **(APHA, 1999)**. Dissolved oxygen (DO) and hydrogen ions (pH), which are important metrics for monitoring water quality, represent the influence of physical, chemical, and biological processes occurring in the water **(EPA, 2014)**. TDS is a measurement of the molecular ionized or micro-granular suspended content of all inorganic and organic substances in a liquid **(WHO, 1996)**. The dissolved solid matter in rivers and their bottoms are the product of erosion processes generated by water currents and soil erosion and erosion from areas next to rivers, wastewater drainage, and industrial use of suspended materials **(Muhammad, 2018).**

2.3. Field Work

Extensive investigations were conducted to examine the condition of the Central Marshes. Through it, a field survey of the water surface level at fifty points was conducted, and the concentration of TDS at nine points was measured to correct some requirements of the mathematical model. A graduated mercury thermometer with a temperature range of 0-100 °C was used to monitor the temperature of both the air and the water. A meter-pH meter was used to determine pH of the water after it was titrated with solutions of standard organization solution buffer with a pH (4, 7, 9). The electrical conductivity of the water was measured with a conductivity meter.

Samples were taken and examined for water's physical and chemical properties. During the collection process, standard methods were used, preserving and transporting samples in accordance with APHA guidelines (2005).

2.4. Laboratory Tests

Azid method modification was used for Winkler, Lind, 1979 to quantify dissolved oxygen. Where 100 ml field-fixed water samples were filtered against a standard sodium thiosulfate solution of 0.125N.0 ($5H_2O.Na_2O_3$) using 1 ml of starch solution as a guide to the reaction endpoint, and the results were expressed in mg/L.

The water turbidity was measured with a Lovibond Turbidity after calibration, the device by special standard forms. The water sample was shaken well and placed in the instrument's glass tube.

2.5. Numerical Simulation Models

A Surface-water Modeling System (SMS 10.1) is utilized to forecast behavior and analyze water quality in Central (Al-Chibayish Marshlands) Marshes. has been used, two models

1- SMS-RMA2: a depth-averaged finite element in two dimensions computational model for hydrodynamics. It uses finite elements to calculate the equations with a depth of integration conservation of two horizontal fluid mass and momentum directions. The inflow discharges at the feeders and the matching water surface heights at the outlets established the upstream and downstream boundary conditions.

2- SMS-RMA4: This finite-element computer model of water quality transport was used to investigate the water quality in the Central Marshes. It involves the movement of a pollutant or the introduction of salinity into a system. It is used to solve the equation for constituent transport. The governing equations in model are an equation for mass conservation, Eq. (1), and two equations for momentum conservation in two directions, Eq. (2), as well as an equation for constituent transport, Eq. (3), **(Donnell, 2009)**, These are the equations:

$$h\frac{\partial u}{\partial t}+hu\frac{\partial u}{\partial x}+hv\frac{\partial u}{\partial y} - \frac{h}{\rho}\left[E\mathrm{xx}\,\frac{\partial^2 u}{\partial x^2} + E\mathrm{xy}\,\frac{\partial^2 u}{\partial y^2}\right] +gh\left[\frac{\partial a}{\partial x} +\frac{\partial h}{\partial x}\right] +\frac{gun^2}{1.486h^{1/6}}(u^2+v^2)^{\wedge}½ -\zeta\, va^2 \cos\varphi -2hv\,\omega\sin\emptyset =0 \qquad (1)$$

$$\frac{\partial h}{\partial t}+h\,\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}+u\,\frac{\partial h}{\partial x} +v\,\frac{\partial h}{\partial y} =0 \qquad (2)$$

$$h\left(\frac{\partial c}{\partial t} +u\,\frac{\partial c}{\partial x} + v\frac{\partial c}{\partial y} - \frac{\partial}{\partial x}\,Dx\,\frac{\partial c}{\partial x} - \frac{\partial}{\partial y}\,Dy\,\frac{\partial c}{\partial y} - \sigma +Kc+\frac{R(c)}{h}\right) =0 \qquad (3)$$

Where:

H=the depth of the water, m, v, u=Cartesian coordinates for velocities, m/sec, x, y=Coordinates in Cartesian, m, T=Time, sec, ρ=Fluid density, kg/m3, Exx=On the x-axis surface, the Eddy viscosity coefficient, in pascal. sec, the Eddy viscosity coefficient, in pascal.sec Pascal.sec, Exy, and Eyx are the shear directions on each surface.ζ=Wind shear confinement based on empirical data, dimensionless, a=Elevation of the Land, m, Va=the speed of the wind, km/h, Ψ=the path of the wind, degrees, c=Pollutant concentration for a particular constituent, mg/l, Dx and Dy=Coefficients, dispersion, and turbulent mixing, m²/sec, Kc=Pollutant decay in the first order, sec^{-1}, R(c)=Level of rainfall/evaporation, dimensionless, and σ=constituent source/sink, mg /m³. sec^{-1}.

3. RESULTS AND DISCUSSIONS

3.1. Assessment of Physical, Chemical, And Biological Characteristics

The physical and chemical parameters of water are utilized to determine its suitability for various applications, two different periods, 27/11/2020, 28/2/2021, as shown in **Table 2.**

Table 2. Average values of physical, chemical, and biological characteristics of water (2020-2021).

Water Quality Parameters	November 2020	February 2021	Aver. values	Unit	Standard Value (I.S)
Water temperature	22.2	16	19.1	°c	35
Turbidity	26	17	21.5	NTU	5
Dissolved oxygen (DO)	6.2	6.3	6.25	mg/L	>4
Total Hardness TH	1698	578	1138	NTU	500
Salinity	1.6	1.9	1.75	PSU	2000
Electrical conductivity (EC)	4955	3469	4212	S/cm	1500
Totally dissolved solids (TDS)	3171	2220	2695.5	mg/L	6.5-8.5
PH	7.8	8.4	8.1		

3.1.1. Temperature of the water

The seasonal cycle of water temperature closely mirrored the seasonal cycle of air temperature due to the shallowness of the marshes. Over ten years, the highest water temperature was recorded during August/2013 was 35.5 °C, while the lowest a degree was recorded during December/2012 was 12.92°C based on CRIM data, as shown in **Fig. 6.**

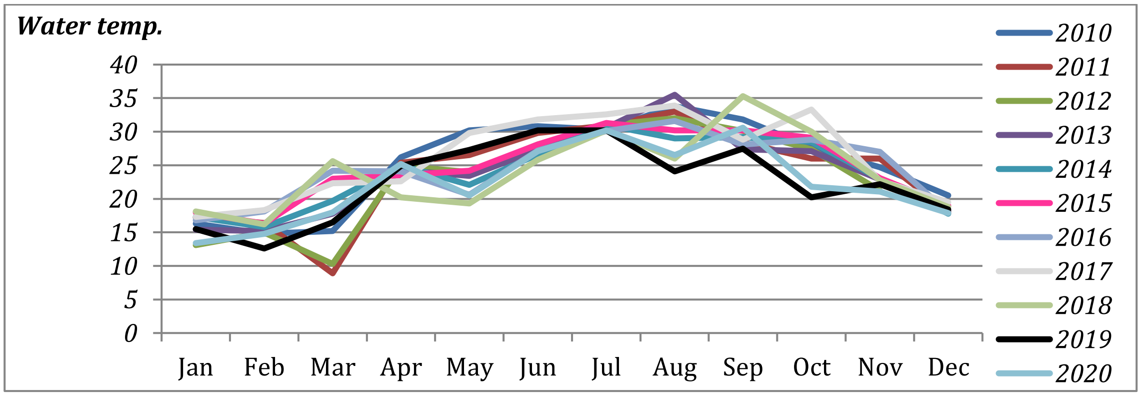

Figure 6. Changes in Water temperature of the study area per month, based on Directorate of Environment of Dhi Qar data.

3.1.2. Potential of hydrogen ions (pH)

pH was generally on the alkaline side. Over the past ten years, the extent of pH (6.9- 8.99). These natural changes were due to interactions with surrounding rock (limestone) and other materials for feeders from the Euphrates river and untreated wastewater.

The marshes' extensive macrophyte beds contributed to high CO_2 levels in the winter, resulting in a lower pH and biological activities of microorganisms that aid in the biodegradation of plant sulfur compounds, reducing the pH.

Because increased temperatures reduced CO_2 solubility and allowed it to escape to the air, pH was mostly unaffected in marshes, resulting in water-air equilibrium. Increased CO_2 should have lowered pH in the summer and fall due to organic material decomposition, as shown in **Fig.7.**

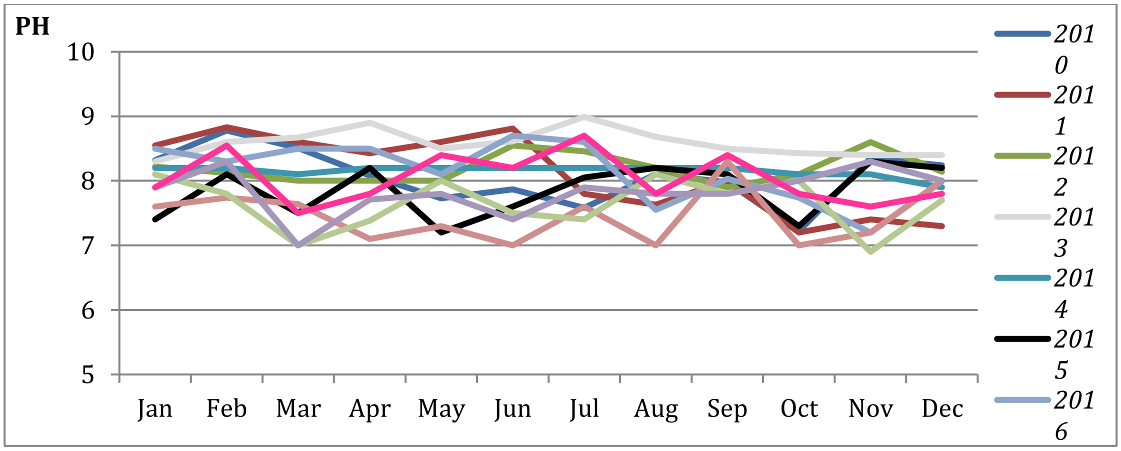

Figure 7. Changes in PH of the study area per month, based on Directorate of Environment of Dhi Qar data.

3.3.3. Turbidity

This study showed the seasonal and local variations of turbidity values, where the highest rate recorded is 110 NTU in June/2010, which may be attributed to a decrease in discharge rates of water coming from the Euphrates River and high temperatures that increase water evaporation. Consequently, increasing the concentration of pollutants causing turbidity, or due to the numerous human activities, as well as the dumping of untreated sewage to the marshes, as shown in **Fig. 8.**

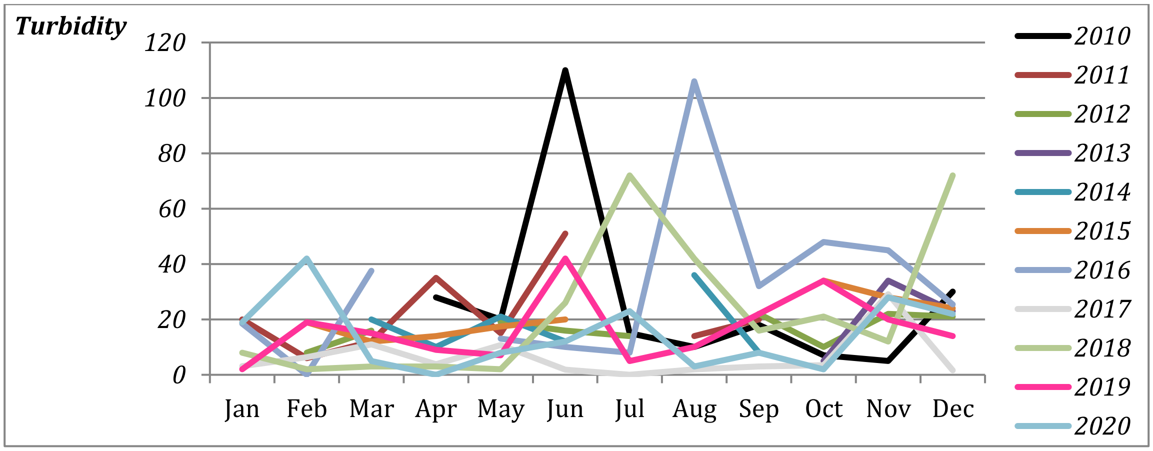

Figure 8. Changes in turbidity of the study area per month, based on Directorate of Environment of Dhi Qar data.

3.3.4. Total Hardness

The elevated value recorded during the fall semester was 5600 NTU. The reason for the high TH values may be due to a decrease in the drainage of water entering the marshes during this season. While the low value was recorded was 640 NTU in the spring semester, as shown in **Fig. 9.**

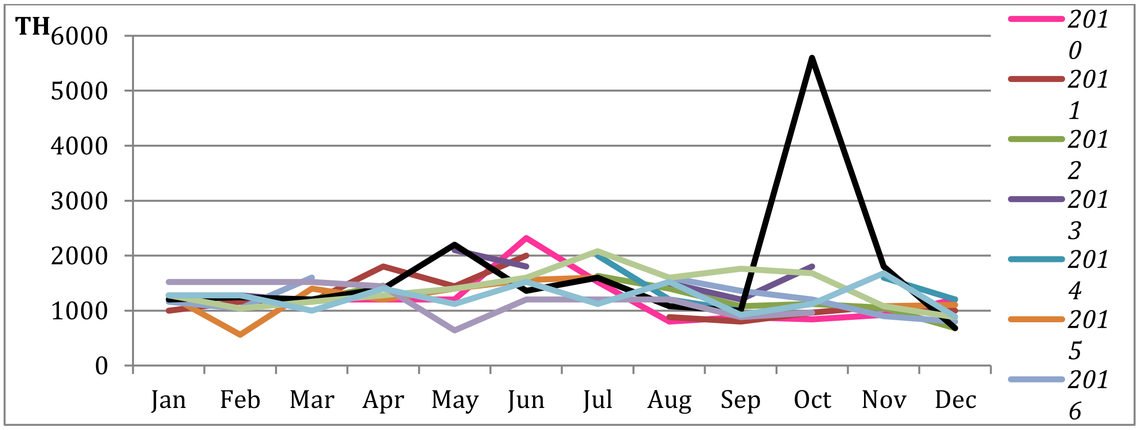

Figure 9. Changes in TH of the study area per month, based on Directorate of Environment of Dhi Qar data.

3.1.5. Electrical Conductivity

The highest electrical conductivity value was recorded at 14030 S/cm within January 2015, and the lowest value of 2505 S/cm during May 2019. The electrical conductivity records revealed an increase in the values of electrical conductivity and salinity in the summer and winter seasons. The increase in the summer may be attributed to the high temperatures, which increase evaporation rates that increase the concentrations of salts and the decomposition products of organic matter (UNEP, 2006). The increase of electrical conductivity and salinity in the winter season may be attributed to the drainage of agricultural land which was washed away and the submergence of dry land in the marshes after they were desertified lands, and this led to an increase in the salt content in the marshes, as shown in **Fig. 10.**

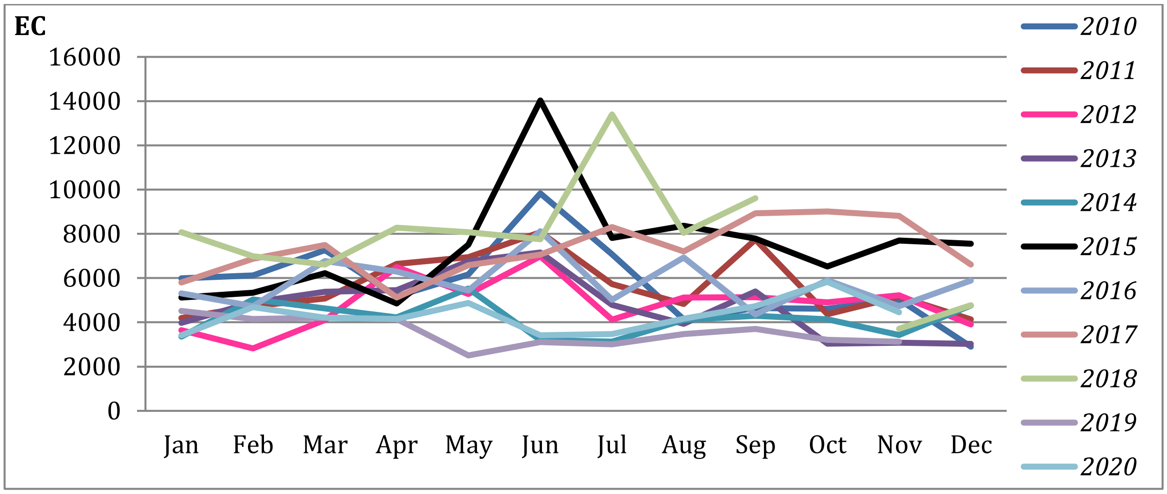

Figure 10. Changes in electrical conductivity of the study area per month, based on Directorate of Environment of Dhi Qar data.

3.1.6. Dissolved Oxygen

DO contents were generally sufficient to maintain aquatic life (i.e., >4 mg/l) and, in fact, were generally high. The marshes' shallowness, dense plant cover, as well as epipelic phytoplankton all contributed to this. Hypoxia was a rare occurrence, as shown in **Fig. 11.**

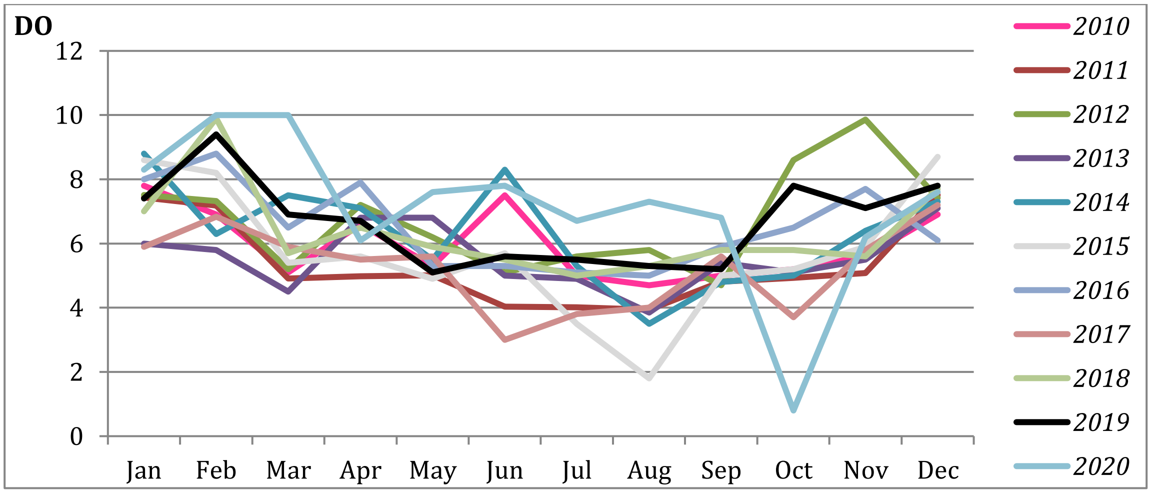

Figure 11. Changes in Dissolved Oxygen of the study area per month, based on Directorate of Environment of Dhi Qar data.

3.1.7. Total Dissolved Solids (TDS)

Monthly fluctuations in total dissolved solids (TDS) values may be due to a decrease in water feeders in some months of the study. Or too high temperature, which caused an increase in water evaporation and an increase in total dissolved solids, as shown in Fig. 12. The TDS values over the ten years studied ranged between the highest value, 10452 in October/2017, and the lowest value, 1386 in December/ 2017.

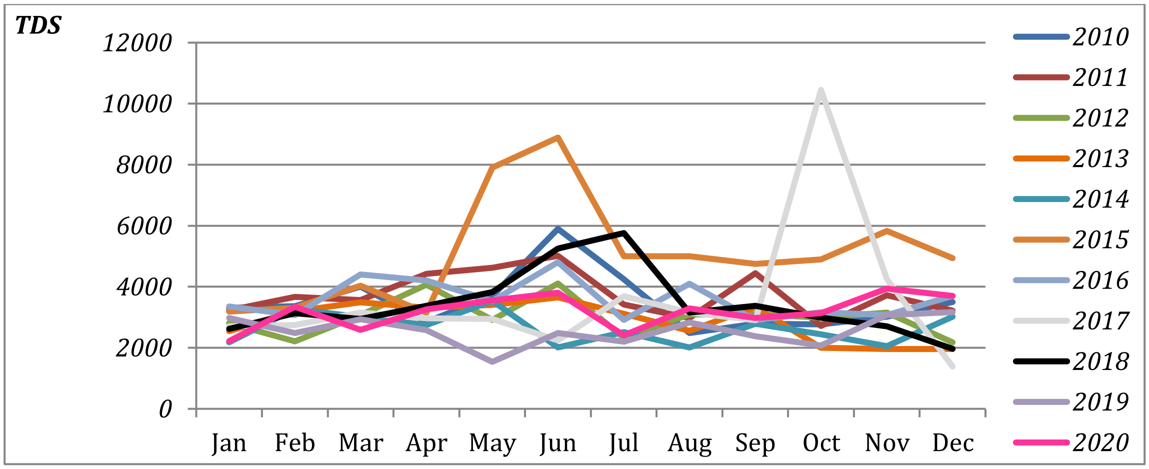

Figure 12. Changes in Total Dissolved Solids of the study area per month, based on Directorate of Environment of Dhi Qar data.

As for the local differences may be due to natural sources, lack of depth, or direct exposure to water the sewage dumped without treatment to the marshes, in addition to the abundance of prominent aquatic plants.

Exceeded the (TDS, turbidity, TH) limits allowed by the Iraqi Standard No. (417) for the year 2009, and the World Health Organization (NTU 5). While, (pH, EC, and DO) did not exceed the standard parameters.

The seasonal fluctuations of the nutrients The quality of water accessing the marshlands from both the Tigris and Euphrates Rivers differs, with the Tigris being better than the Euphrates.

3.2. RESULTS OF THE NUMERICAL MODELS

3.2.1. Identifying the Outlets' Locations

It must be provided with an adequate outlet to wash out the collected salts and lower the salt concentration within Central Marshes (s). The outlet(s) must be in the marsh's southeastern section, near Al-Fuhood-Al-Medaina Road in the downstream end, where the topography assists flow toward the outlet(s), as shown in **Fig.2.** The location of the outlets and scenarios is shown in **Table 3.**

Table 3. The Locations of suggested outlets and proposed scenarios.

Locations	Name	Easting	Northing	scenario	Tested location
1	Abu gedaea´a	0705330	3427912	M1	1,2,5
2	Al-Saba´a	0706064	3427963	M2	3,4
3	Al-Badreea	0707330	3428163	M3	1,2
4	Kehala	0708042	3428240		
5	Jilae	0709717	3428331		

3.2.2. Results of the Two Models

Two cases with high and low discharge, each case have three scenarios were implementation. The feeders' position, TDS concentration, discharge, the outlet's location and topographic features upstream, and evapo-transpiration all impact velocity profiles, water depth, and TDS concentration.

Figs.13, and **14.** show the outcomes of the mathematical model in case (1): the velocity profile and TDS concentration inside Central Marshes. Because of the feeder supplying the marsh from the Tigris River, the concentration of TDS in the north portion of the marsh is relatively low. The southern section of this area has the highest TDS concentration because all feeders supply the marsh from the Euphrates River. The Euphrates River flows from northern Iraq to its south in Lower Faris formation, which is composed of Calcite, gypsum, and dolomite rocks, leading to a rise in the salt concentration in the water as a consequence of the disintegration of these types of rocks.

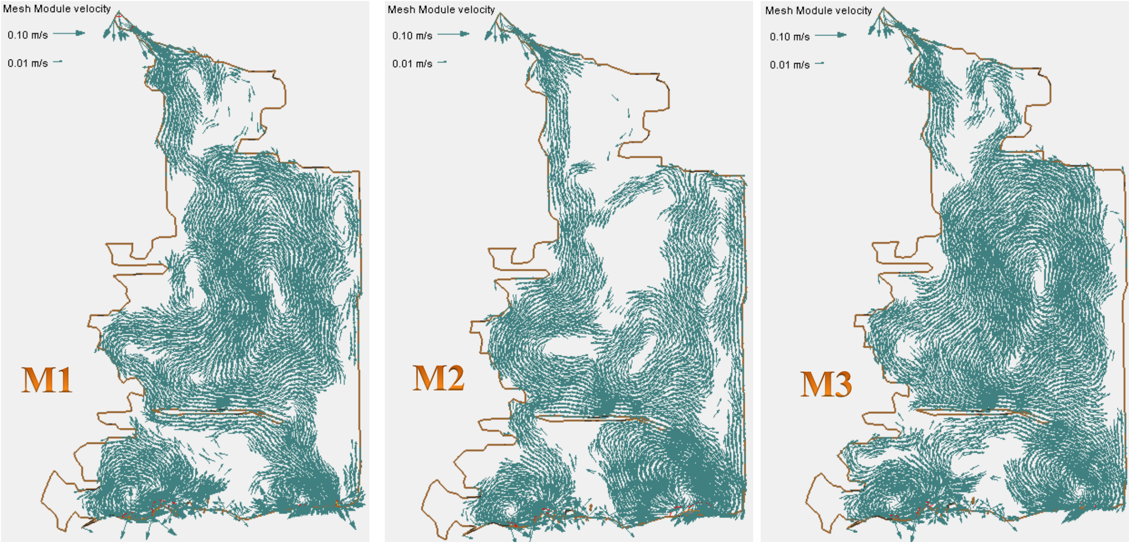

Figure 13. The velocity pattern with Central Marshes, in case1.

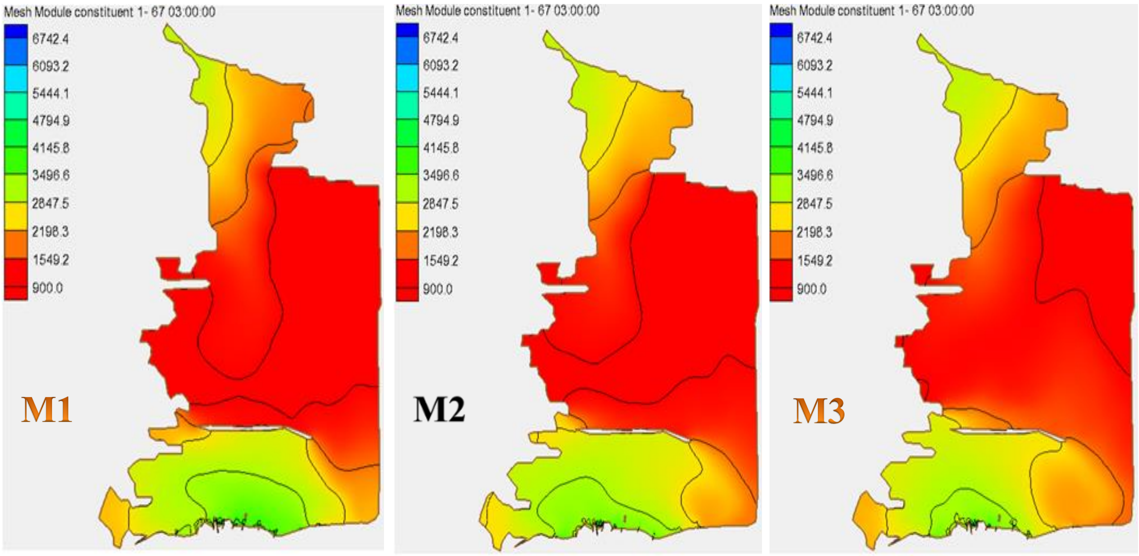

Figure 14. The TDS distribution with Central Marshes, in case1.

Figs. 15 and 16. show the outcomes of the mathematical model in case (2). The distribution differed for both speeds and TDS from the first case, due to the difference in the limits of the restrictions, where the internal drainage of the Central Marshes is less, and the influence of the climate, where the temperature is higher. The quality of water entering the marshlands from the Tigris is generally better than the Euphrates.

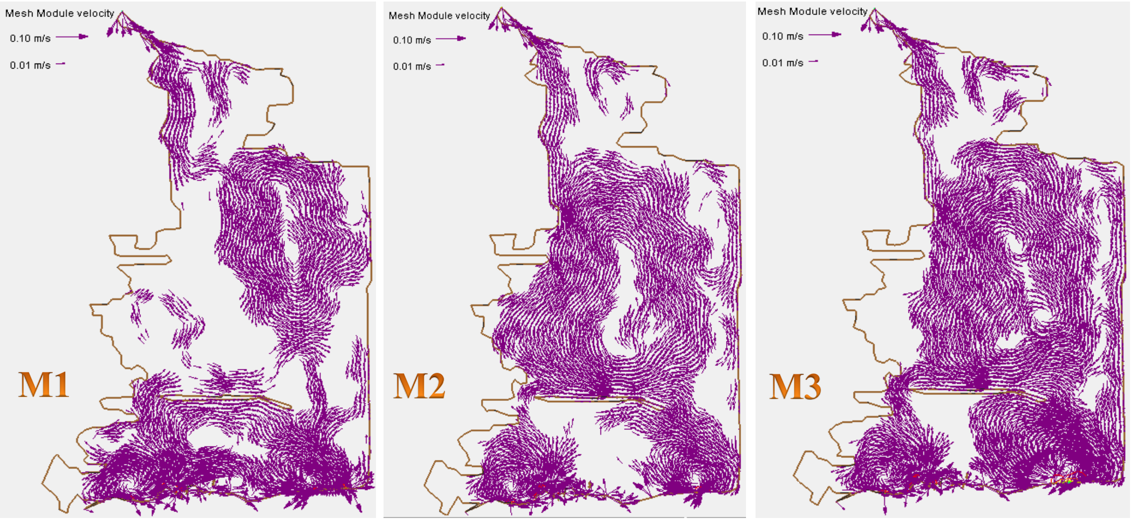

Figure 15. The velocity pattern with Central Marshes, in case2.

Stagnation areas are large and unacceptable in the case of the first scenario (M1) because it causes the concentration of salts in those areas.

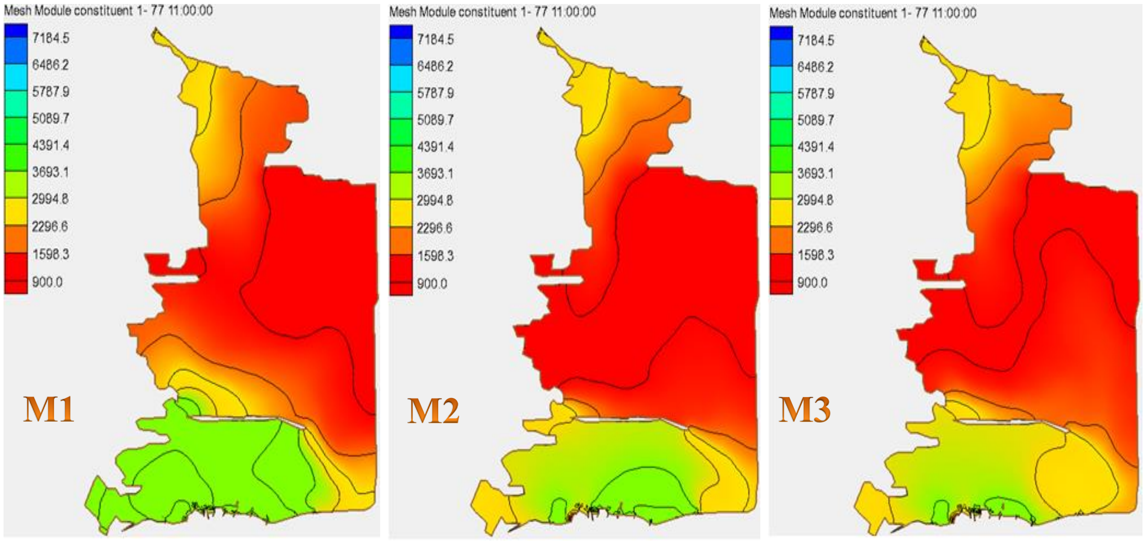

Figure 16. The TDS distribution with Central Marshes, in case2.

The marsh's outlet position also influences the marsh's velocity pattern. The Central Marshes mathematical model, which was created using SMS's RMA2, produced good current velocity verification results compared to observation data. In each cases speed range is (0.01- 0.1) m/s. In both cases, the velocity distribution in scenario M3 is the desired state to reduce stagnation areas. Furthermore, the TDS distribution pattern was thoroughly studied by the established water quality model. **Tables 4,** and **5** displays the percentage of deteriorated marshland compared to the total marshland area and the TDS concentration range within this area. The best outlet(s) was identified to treat the poor water quality problem in the CM, the region's severe climate fluctuations, as well as the maximum and minimum drainage conditions, were considered. In two cases, scenario M3 produced the best results in terms of lowering salt levels in the marshes. The results of the two cases were according to the sequence of pollutant reduction as follows:

Table 4. The results of numerical models, case 1.

Scenario	QT input = 77.02 m³/s, and water surface elevation of 1.77 m.a.m.s.l.		
	Discharge of outlet, m3/s	Most deteriorated area %	range of TDS, mg/l
M1	15.78	24.71 %	2847.5 – 4145.8
M2	36.3	24.08 %	2847.5 – 4145.8
M3	27.16	23.31 %	2847.5 – 3496.6

Table 5. The results of numerical models, case 2.

Scenario	QT input = 62 m³/s, and water surface elevation is 1.52 m.a.m.s.l.		
	Discharge of outlet, m3/s	Most deteriorated area %	range of TDS, mg/l
M1	16.83	24.99 %	2994.8 – 4391.4
M2	13.25	25.04 %	3693.1 – 5089.7
M3	25.9	20.18 %	2994.8 – 3693.1

4. CONCLUSIONS

Based on the results obtained from this study:

- The spatial and temporal variation of all components of the studied water quality are affected by many factors: the terrain, the difference in the density of plants, the untreated sewage that is being disposed of in CM, the weather, as well as the feeder's source from the Tigris and Euphrates Rivers, the feeders of the Euphrates River, which vary in the pollution's percentage, especially concentration of salts. As approach from Al Qurna, the concentration reached 9,820 ppm in June 2020 in Jahala. The quality of water entering the marshlands from the Tigris is generally better than in the Euphrates River.
- The measured and recorded data during the ten years showed a significant increase in the values of some of the measured variables, the (TDS, turbidity, TH) exceeded limits allowed by the Iraqi Standard No. (417) for the year 2009, and the World Health Organization (NTU 5). While (pH , EC, and DO) are within the standard parameters, providing a danger to humans who use the marsh for drinking and other purposes. The increase occurs more in summer than in winter. pH has generally been on the alkaline side.
- In 2015, the Central Marshes experienced a shortage of water supply compared to the ten studied years, which led to a significant decrease in water quality, Qmax.= 43.2m³/s, While 2019 represented a turning point in the quality of water to increase inflow Q max.= 244.4m³/s.
- The water temperatures in the Central Marshes fluctuated greatly throughout the year between (10.3 to 35.5) ºC.
- The hydrodynamic properties revealed the necessity for one or more outlets to drain marsh water and good distribution of TDS Marshes area. Furthermore, studies have shown that using these outlets will considerably improve water quality. After taking into account the effect of drainage on neighboring lands, the best site and the necessary path for drainage are M3.

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