Effect of the Iranian Seperation Dikes on the Water Salinity Patterns Within Al Huweizah Marsh

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ABSTRACT

Al Huweizah Marsh is considered as the largest marsh at the southern part of Iraq. About one third of the marsh is located within the Iranian territory. Iran began to construct earth dikes along the Iraqi-Iranian international borders to separate the Iranian part of the marsh.

The electrical conductivity, EC, value was adopted to be the indicator for the water salinity within the marsh. A steady two-dimensional water quality routing model was implemented by using the RMA2 and RMA4 softwares within the SMS computer package to estimate the distribution of the EC values within the marsh seasonally during the wet, moderate and dry water years. The EC distribution Patterns were estimated considering the expected two cases of the marsh future hydrological and geometrical conditions of the marsh, Case 1: without existence of the earth dikes and Case2: with the existence of the earth dikes.

The estimated distribution patterns of EC values showed that the construction of the earth dikes, Case2, deteriorate the water salinity within most of the Iraqi part of the marsh during the four seasons of the wet, moderate and dry water years. During the wet and moderate years, the EC values are greater than the maximum allowable limits within most of the Iraqi part of the marsh except small portions near the outfall of the Iraqi feeders of the marsh and the lower portion of the southern part of the marsh during winter of the moderate years. While during the four seasons of the dry years, the marsh water is stagnant and the EC values are much greater than the maximum allowable limits.

Key Words: Separation dikes, water quality, distribution patterns, SMS, RMA, Al Huweizah.

تأثير السدة الايرانية الفاصلة على انماط توزيع ملوحة المياه في هور الحويزة

الخلاصة

يعتبر هور الحويزة اكبر الاهوار في جنوب العراق. ما يقارب ثلث من مساحة هور الحويزة يقع ضمن الاراضي الايرانية. بدأ الجانب الايراني بأنشاء سداد ترابية على طول الحدود الدولية العراقية-الايرانية لفصل جزء الهور الواقع ضمن الاراضي الايرانية. تم اعتماد قيمة التوصيلية الكهربائية كمؤشر لنوعية المياه داخل الهور. تم اعداد نموذج للجريان الثابت ثنائي البعد لإستنتباع ملوحة المياه بإستخدام البرامج RMA4, RMA2 ضمن الحقيبة البرمجية SMS لإيجاد انماط توزيع قيم التوصيلية الكهربائية داخل الهور فصلياً خلال السنوات الفيضانية والمعتدلة والجافة لحالتي الهور المتوقعة مستقبلاً من الناحية الهيدرولوجية وتغير حدود الهور، الحالة الاولي: بدون وجود السداد الترابية والحالة الثانية: مع وجود السداد الترابية.

بينت انماط توزيع قيم التوصيلية الكهربائية التي تم ايجادها إن إنشاء السداد الترابية (الحالة الثانية) يؤدي الى تدهور نوعية مياه الهور في معظم مساحة الجزء العراقي من الهور خلال الفصول الاربعة للسنوات الفيضانية والمعتدله والجافة. خلال السنوات الفيضانية والمعتدلة تكون قيم التوصيلية الكهربائية اكبر من الحد الاعلى للقيم المسموح بها في معظم مساحة الجزء العراقي من الهور ماعدا أجزاء صغيرة بالقرب من مصبات المغذيات العراقية في الهور وفي القسم السفلي من الجزء الجنوبي من الهور خلال فصل الشتاء في السنوات المعتدلة. في حين تكون مياه الهور راكدة وقيم التوصيلية الكهربائية اكبر بكثير من الحد الاعلى للقيم المسموح بها في كل مساحة الهور خلال الفصول الاربعة في السنوات الجافة.

INTRODUCTION

Al Huweizah Marsh, **Fig. 1,** is considered as the largest marsh at the southern part of Iraq. It is located at the east side of Tigris River at Maissan and Al Basrah Governorates. The eastern part of this marsh (about one third of the total area) is located beyond the Iranian borders.

The main water resources of Al Huweizah Marsh, **Fig. 1**, can be classified into two types depending on the existence of water control structures. The first, controlled feeders, are Al Msharah, and Al Ka'hla Rivers which are sharing the same intake located north of Al Amarah Barrage on Tigris River and controlled by head regulators located upstream of each river. The second, uncontrolled feeders are Al Karkheh River and AsSanna'f Marsh, which are feed by AtTeeb, Dwayreach, Kmait Rivers, the surface runoff of AShama'ashir area and the drain water of Sa'ad River irrigation project.

The main discharge outlets of Al Huweizah Marsh are Al Kassara and AsSwaib Rivers.

Al Kassara River water is discharged to Tigris River through two sets of pipes. These pipes will be replaced by a control structure with a design discharge of $125m^3$/sec. AsSwaib River flows from the southern part of Al Huweizah Marsh and directly outfalls in Shat Al Arab River with an average flow of 600 m^3/sec. A control structure with a design discharge of $200m^3$/sec has been designed to control the outflow of this river into Shat Al Arab River (Ministry of Water Resources, el. at 2007).

Agricultural and industrial projects are constructed and developed along the two sides of Al Karkheh River within the Iranian territories. The river was dammed and finally earth dikes were proposed to construct along the Iraq- Iran boundary to separate the Iranian part of the marsh. This will affect the ecological system of the marsh because the ecology of Al Huweizah Marsh is closely related to the inflowing freshwater resources from Al Karkheh River.

The Iranian border dike (presently under construction) crosses through the marsh and bisects the existing marsh into two parts, thus Al Azim Marsh (in Iran) is functioning as a single isolated marsh. The presuming dike elevation is 6m a.m.s.l. (UNEP and IRAN, 2004). The reduced flowing water from Al Karkheh River into the marsh, using of Al Karkheh River water for irrigation of the nearby areas and the drainage of extra water into the marsh will deteriorate the water quality of the marsh.

Hyder A. Al Thamiry, 2009, developed a hydrological routing model to evaluate the hydrological effect of constructing this proposed dike on the Iraqi part of Al Huweizah Marsh during wet, moderate and dry water years.

This research aims to evaluate the effect of the proposed Iranian separation dike on the water quality distribution of Al Huweizah Marsh based on the results of the hydrological routing model that was developed by Hyder, 2009. A steady two-dimensional hydraulic model was implemented using the SMS software to evaluate this effect.

TOPOGRAPHY OF THE MARSH

A Digital Elevation Model (DEM) of the whole marsh area and of the Iraqi part of the marsh, **Fig. 2**, was developed using the topographical survey carried out for the Iraqi part of Al Huweizah Marsh using the ultra sound device, Ministry of Water Resources-CRIM, 2007, the topographical map of the Iranian part of the marsh which was presented by UNEP (UNEP and IRAN, 2004) and with the combined support of various maps and satellite images.

HYDROLOGICAL STATE OF THE MARSH

According to the expected hydrological and geometrical future condition of the marsh the hydrological state of the marsh can be classified into two cases:

Case1: The expected future condition of the marsh with the existence of the outlet control structures (Al Kassarah and AsSwaib) and without existence of the dikes, the marsh area will be considered as one unit, and the proposed outlet control structures.

Case2: The expected future condition of the marsh with the existence of the presumed dike and outlet control structures. Assuming the marsh will be bisected into Iraqi and Iranian parts.

A schematic diagram for the hydrological interference between the Iraqi Part and the functional and degraded Iranian part of the marsh is shown in **Fig. 3**.

Based on the results of the hydrological routing (Hyder, 2009) the seasonal inflow discharges of the marsh feeders and the water surface elevation within the marsh for the wet, moderate and dry water year were estimated for the two cases and listed in T**able 1**.

WATER QUALITY OF THE MARSH

The water quality within Al Huweizah Marsh varies with time depending on the source of water and whether the water passes urban areas. Except the dissolved Oxygen, DO, the electrical conductivity, EC (or TDS), all other contaminants are about within the acceptable limits for drinking water standards. The maximum recorded EC at Al Msharah River, AzZubair River, Um AtToos River, Al Husa'chi River, Al Kassara River, and AsSwaib River stations is slightly higher than the acceptable limit. While the maximum recorded Ec at AsSanna'f Marsh outfall , AtTeeb River, Dwayreach River, Kmait River, and Sa'ad Drain let stations was 9000 µS/cm and to be higher than the acceptable limit in most of the measurements (Ministry of Water Resources-CRIM, 2007).

Available information on Karkheh River water quality was restricted to total dissolved solids (TDS), pH, Electrical conductivity (EC), anions and cations for the main stations UNEP and IRAN, 2004. The electrical conductivity (EC) of the water was adopted to be the indicator of the water salinity. This parameter is adopted because it gives indication about the concentration of TDS and because of the availability of recorded data concerning this contaminant.

The distribution patterns of EC within the marsh area are studied according to the recorded data of the Iraqi feeders and the available data of Al Karkheh River. The water quality of Tigris River was adopted for the Iraqi feeders of the marsh. The available averaged values for the EC of Al Karkheh River at the Marsh inlet will be adopted for wet, Moderate and dry years.

Since there is no predicted data of any contaminant within the two Iranian part of the marsh, the functional and degraded Iranian marshes, the EC of Kmait Flood Escape station (E: 705094, N: 3539729) was adopted to simulate the future EC of these marshes. The main points of similarity between the selected station and the marshes are:

- Kmait flood escape is like a blind drain since the inflow into this escape is from Sa'ad irrigation project and during Moderate and dry years no water will be spilled into Al Huweizah marsh through AsSanna'f Marsh. This behavior is similar to that of the Functional and Degraded Iranian marshes.
- The evaporation and precipitation are approximately equal to that of the Iranian side of the marsh.

The maximum recorded value of EC in Kmait flood escape was adopted to be the EC value of the functional and degraded Iranian marshes during the Moderate water year while the average of the EC values was used for the wet year. Since the results of the hydrological routing, Hyder A. Al Thamiry, show that after construction of the proposed separation dike there will be no flow from the Iranian part of the marsh to the Iraqi part of the marsh during the dry year. The adopted values of EC for wet, Moderate and dry water years of each feeder for the two cases are listed in **Table 2**.

STEADY TWO –DIMENSIONAL WATER QUALITY MODEL

A steady two-dimensional water quality model has been implemented by using the RMA4 model within the SMS computer package (Brigham Young University-USA, 2009) to simulate the water quality distribution within the marsh.

It is a finite element water quality transport numerical model in which the depth concentration distribution is assumed uniform. It computes concentrations for up to 6 constituents, either conservative or non-conservative, within the one-and/or two-dimensional computational mesh domain. The water quality model, RMA4, is designed to simulate the depth-average advection-diffusion process in an aquatic environment.

The RMA4 model requires an RMA2 model within the same package which is a two-dimensional depth averaged finite element hydrodynamic numerical model to be implemented first. It computes water surface elevations and horizontal velocity components for sub critical, free surface two-dimensional flow fields.

The results of the RMA2 model, water depth, water surface and velocity pattern, will be the input data for the finite element water quality transport numerical model, RMA4 model.

RMA2 MODEL

RMA2 model computes a finite element solution of the Reynolds form of the Navier-Stokes equations for turbulent flow. Friction is calculated with the Manning's or Chezy equation, and eddy viscosity coefficients are used to define turbulence characteristics.

According to the considered two cases of the marsh future condition, **Fig. 2**, a triangular finite element mesh of the whole marsh has been developed over an area approximately 1800 km^2, where the area of the Iraqi part is about 1300 km^2. These meshes are built using an "adaptive tessellation" technique.

The developed Digital Elevation Model (DEM), **Fig. 2,** of the whole marsh area and the Iraqi part of the marsh was used to be the topographical data that are required to develop these models. These data were sampled onto the computational nodes of the mesh using inverse weighted interpolation scheme. Slope adjustments were necessary at some locations such as the banks of the main canals inside the marsh. This modification helps model solution stability. The eddy viscosity must be assigned to allow the model to solve the equations. As typical for all finite element models, the eddy viscosity affects stability and turbulent fluid characteristics. During the model preparation, a solution was prepared for a range of eddy viscosities to investigate the model's sensitivity. Ultimately, two different techniques were adopted in the definition of the eddy viscosity number. The first specifies directly an eddy viscosity value and the second let the model automatically compute an appropriate value via the "automatic Peclet number". The Peclet number is defined by the following equation:

$$Peclet = \frac{\rho\, u\, dx}{E} \qquad (1)$$

Where ρ is the fluid density, u is the average element velocity, dx is the length of the element in the stream wise direction and E is the eddy viscosity.

Both definitions of the eddy viscosity were used within the model and the model was let to decide the more appropriate method to be used. Wetting and drying parameters had to be specified as part of the geometry. The complete definition of the model geometry requires friction factors to be assigned at each mesh element. The friction factors of the soil were divided into four values corresponding to the four soil zones which were classified according to the water depth and the existence of plants within the marsh area using the available satellite images and site visits, these values are listed in T**able 3** and shown in **Fig. 4**. It is to be noticed that the friction factor for water depth less than 2 m is listed in this table. When the water depth within the marsh is deeper the factor will be adopted as 0.07 for all soils (Brigham Young University-USA, 2009).

RMA2 MODEL BOUNDARY CONDITIONS

As previously mentioned, there are two hydraulic models; the first is of the whole marsh area and the second for the Iraqi part. The downstream boundary conditions for both models are the same which are Al Kassara and AsSwaib Rivers while the difference in the upstream boundary conditions is the feeding water that flow into the marsh from Al Karkheh River. The reason of this difference is the existence of the proposed separation Iranian dike that will prevent the incoming water from Al Karkheh River to flow into the Iraqi part, when the water levels within the Iranian part is lower that 6 m.a.s.l. The water will spill over this dike when the water level exceeds 6 m.a.s.l.

Al Huweizah Marsh has five inlets, as shown in **Fig. 5**:

- Al Karkheh River, within the Iranian borders, which is divided into three tributaries when joining Al Huweizah Marsh, was treated as a one source point. This feeder will be replaced by a line source along the Iraq-Iran border that represents the inflow into Iraqi part of the marsh from Functional and Degraded Iranian.
- AsSanna'f Marsh and Al Msharah River outfall were treated as a one source point since Al Msharah River flows into AsSanna'f Marsh before AsSanna'f Marsh outfall at Al Huweizah Marsh.
- Um AtToos River outlet.
- Al Husa'chi River outlet.
- AzZubair River outlet.

The marsh has two outlets as shown in **Fig. 5**:

- Al Kassara River
- Al AsSwaib River.

The upstream boundary conditions are constant inflow from each feeder for the two cases while the down stream boundary condition is the water surface elevations at the marsh outlets for the two cases. Results of Hyder, 2009 hydrological routing study, T**able 1**, were adopted to be the boundary conditions for the RMA2 model of the two cases.

RMA4 MODEL

Geometric data of the RMA2 model and results of applying this model for the two cases, Case 1 and Case 2, seasonally for the wet, moderate and dry water years were the data base of the RMA4 (a finite element water quality transport numerical model in which the depth concentration distribution is assumed uniform).

DIFFUSION COEFFICIENT

In the RMA4 model the diffusion coefficient (D) can be specified either manually based on the previous studies or automatically using Peclet number. In this research the diffusion coefficient was specified automatically by using Peclet number.

The model automatically adjusts D after each time step, based upon a provided Peclet number, depending upon the element size and calculated velocity within each element. The Peclet methodology is very similar to that of RMA2. The Peclet number is a dimensionless parameter. However, for RMA4, the Peclet number (P) takes the form (Brigham Young University-USA, 2009).

$$P = \frac{udx}{D} \qquad (2)$$

hence

$$D = \frac{E}{\rho} \qquad (3)$$

Where

P : Peclet number (unit less)
ρ : Fluid density (kg/m^3)
u : average elemental velocity calculated at the guess points (m/sec)
E : Eddy Viscosity for RMA2
D: diffusion coefficient for RMA4 (m^2/sec)
dx=length of element (m)

RMA4 MODEL BOUNDARY CONDITIONS

As has been previously mentioned, there are two hydraulic models and two water quality models; the first couple of models are of the whole marsh area and the second are of the Iraqi part of the marsh.

The upstream boundary conditions are the EC values (electrical conductivity) of the inflow water from each feeder**, Table 2**.

No Downstream boundary conditions are needed since the diffusion coefficient is auto-calculating and the results were compared with that of seasonal observation in Moderate year.

RESULTS

Results of applying the RMA4 model for the EC during the four seasons, Autumn, Winter, Spring and Summer for the Wet, Moderate, and Dry water years for **Case1** and **Case 2**, are shown in **Figs. 6** to **17,** these figures show the seasonal variations in the distribution of the EC within the marsh and the effect of constructing the presuming dike on the values and distribution of this contaminant. These results give a good explanation for the effect of constructing the presuming dike on the water quality of the marsh.

These results show that construction of the presuming dike causes the following:

1- Wet water year:

a. Autumn: The value of EC will increase within the Iraqi part of the marsh. The value of EC will be greater than the maximum acceptable limits of the international specification for drinking and agricultural uses (WHO, 2008 and FAW, 1994) 2500μs/cm, in the Southern zone of the marsh. This is due to ceasing of the flow from Al Karkheh River.
b. Winter: The value of EC will increase within the Iraqi part of the marsh due to ceasing of the flow from Al Karkheh River, but the increase of inflow discharge of the Iraqi feeders reduces this effect. The value of EC will increase to greater than 2500μs/cm in the lower part of the Southern zone of the marsh.
c. Spring: In this season the inflow from the Functional and Degraded parts of the marsh start to flow into the Iraqi part of the marsh this causes increase in the value of EC within the Iraqi part of the marsh especially in the

Eastern zone of this part where EC will be greater than 2500µs/cm. Furthermore; existence of Ajerda dike, **Fig. 5**, obstructing the flow into the southern zone of the marsh and impounding the bad quality water above this dike.

d. Summer: In this season the inflow from the degraded part of the marsh will stop while that of the Functional part will be continued and the inflow from the Iraqi feeders of the marsh will decrease. So, the value of EC will increase especially in the northern zone of the Iraqi part of the marsh where EC will be greater than 2500µs/cm.

2- Moderate water year:

a. Autumn: Ceasing of Al Karkheh River flow into the marsh in this season causes increase in the EC value within most of the marsh area, EC>2500µs/cm, except a small zone near the outfalls of the Iraqi feeders of the marsh.

b. Winter: The value of EC will increase within the Iraqi part of the marsh due to ceasing of the inflow from Al Karkheh River, but the increase of inflow discharge of the Iraqi feeders reduces this effect. The value of EC will increase to 2000µs/cm in the lower part of the Southern zone of the marsh. This value is within the acceptable limit.

c. Spring: In this season the drainage water from the Iranian agricultural areas start to inflow from the Functional part of the marsh into the Iraqi part of the marsh. This causes increase in the EC value within most of the marsh area, EC>2500µs/cm, except a small area near the outfalls of the Iraqi feeders of the marsh and a small area in the southern zone of the marsh. Furthermore; existence of Ajerda dike, **Fig. 7**, obstructing the flow into the southern zone of the marsh and impounding the bad quality water above this dike and this increases the EC value to greater than 6500 µs/cm in the middle zone of the marsh.

d. Summer: In this season the inflow from the Functional part of the marsh decreases and its effect extends as a strip along the dike and near Ajerda dike where EC>2500 µs/cm.

3- Dry water year:

a. Autumn: In this season, ceasing of Al Karkheh River flow into the marsh and decreasing the flow from the Iraqi feeders cause decrease in the water depth of the marsh and then the flow within the marsh will stop. The EC value will be greater than 3200 µs/cm within most of the marsh area.

b. Winter: Ceasing of Al Karkheh River inflow into the marsh in this season causes increase in the EC value, EC>3200 µs/cm within the whole marsh area.

c. Spring: Although there is a difference in the water depth within the marsh area during Winter and Spring, but the values of EC in this season are similar to that of Winter. This is because the marsh is fed completely from the Iraqi feeders

d. Summer: In this season the inflow from the Iraqi feeders will decrease and there is no flow from Al Karkheh River So, the value of EC will increase to more than 4500 µs/cm within the whole marsh area.

CONCLUSIONS

Al Karkheh River is one of the most important feeding sources of the marsh. Constructing the presuming dike decreases the marsh area and the inflow discharges that are vital to conserve expediential water depth within the marsh and to insure suitable flow within the marsh with suitable water quality distribution patterns.

Constructing the Iranian separation dike and discharge the drainage water of the nearby agricultural project into the Iranian part of the marsh and then into the Iraqi part of the marsh during the wet years deteriorates the water quality of the marsh. The EC will be greater than the maximum acceptable limits within most of the marsh area during the four seasons of the wet and moderate year.

During winter in the moderate years, the increase of inflow discharges of the Iraq feeders reducing this effect. Therefore, the value of EC in the lower part of the Southern zone of the marsh will be within the acceptable limit. During the dry years, cease of Al Karkheh River inflow into the marsh synchronous with the decrease of inflow discharge from the Iraqi feeders. This causes decrease in the water surface elevation and marsh area and ceases the flow within the marsh. The marsh water will be stagnant and the EC values will be much greater than the maximum allowable limits.

To prevent the deterioration of the ecological system of the Iraqi part of the marsh, the inflow discharge into the marsh from the controlled Iraqi feeders, Al Msharah and Al Ka'hla, must be increased to preserve the concentrations of water contaminants within the acceptable limits and to prevent any losses from the area of the Iraqi part of the marsh, the chocking in water flow due to Ajerda dike must be removed, hydrological and water quality monitoring stations must be constructed within the marsh and on all the feeders and outlets of the marsh and the pollution sources which affect the marsh ecological system must be studied.

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Table 1. Seasonal inflow (m^3/sec) from the marsh feeders and water surface elevation within the marsh for Case 1 and 2. (after Hayder A. Al thamiry, 2009).

Case	Season	Discharge (m^3/sec)																		Marsh water surface Elevation (m.a.m.s.l)		
		AsSannaf			AzZubair			UmAt Toos			AlHusa'chi			Al Karkheh								
		Wet	Moderate	Dry	Wet	Moderate	Dry	Wet	Moderate	Dry	Wet	Moderate	Dry	Wet	Moderate	Dry				Wet	Moderate	Dry
Case 1	Autumn	25	12	5	20	8	2	33	13	3	48	18	5	98	97	57				4.5	3.8	3.5
	Winter	123	70	14	30	18	2	49	31	3	69	44	5	615	263	80				6.3	4.9	3.7
	Spring	33	20	11	30	10	1	49	17	2	69	23	3	635	227	70				8.6	5.6	3.9
	Summer	20	11	5	15	7	2	25	11	3	35	16	4	90	41	5				6.9	4.3	2.7
Case 2														Functional			Degraded					
														Wet	Moderate	Dry	Wet	Moderate	Dry			
	Autumn	25	12	5	20	8	2	33	13	3	48	18	5	0	0	0	0	0	0	4.3	3.1	2.8
	Winter	123	70	14	30	18	2	49	31	3	69	44	5	0	7	0	0	0	0	4.8	3.8	3.0
	Spring	33	20	11	30	10	1	49	17	2	69	23	3	304	113	0	67	0	0	7.2	4.9	3.2
	Summer	20	11	5	15	7	2	25	11	3	35	16	4	154	5	0	0	0	0	5.9	3.7	2.6

Table 2: Seasonal Electrical Conductivity (Ec (μS/cm)) values of Al Huweizah Marsh feeders (after CRIM, 2007, MoWRS, 2007, and UNEP and IRAN, 2004).

Dry year							
Feeder	AsSanna'f	AzZubair	Um AtToos	Husa'chi	Kassara	AsSwaib	Al Karkheh River (averaged values)
Autumn	3342	3342	3342	3342	Estimated from the model		2279
Winter	4018	4018	4018	4018			1160
Spring	4477	4477	4477	4477			961
Summer	3422	3422	3422	3422			1730
Wet year							
Autumn	1410	1410	1410	1410	Estimated from the model		2279
Winter	1933	1933	1933	1933			1160
Spring	1410	1410	1410	1410			961
Summer	1442	1442	1442	1442			1730
Moderate year							
Autumn	1545	1536	1264	1599	1741	2583	2279
Winter	1162	1144	1135	1176	1376	2343	1160
Spring	1219	1204	1200	1227	1596	2455	961
Summer	1280	1286	1287	1300	1675	2600	1730
The minimum, maximum and average values of the conductivity (Ec) values for Kmait flood Escape are 5320, 8600 and 6960 μS/cm, respectively.							

Table 3: Friction factor for different soil zone (Brigham Young University-USA, 2009).

Soil Zone	Friction factor
1	0.030
2	0.070
3	0.040
4	0.045

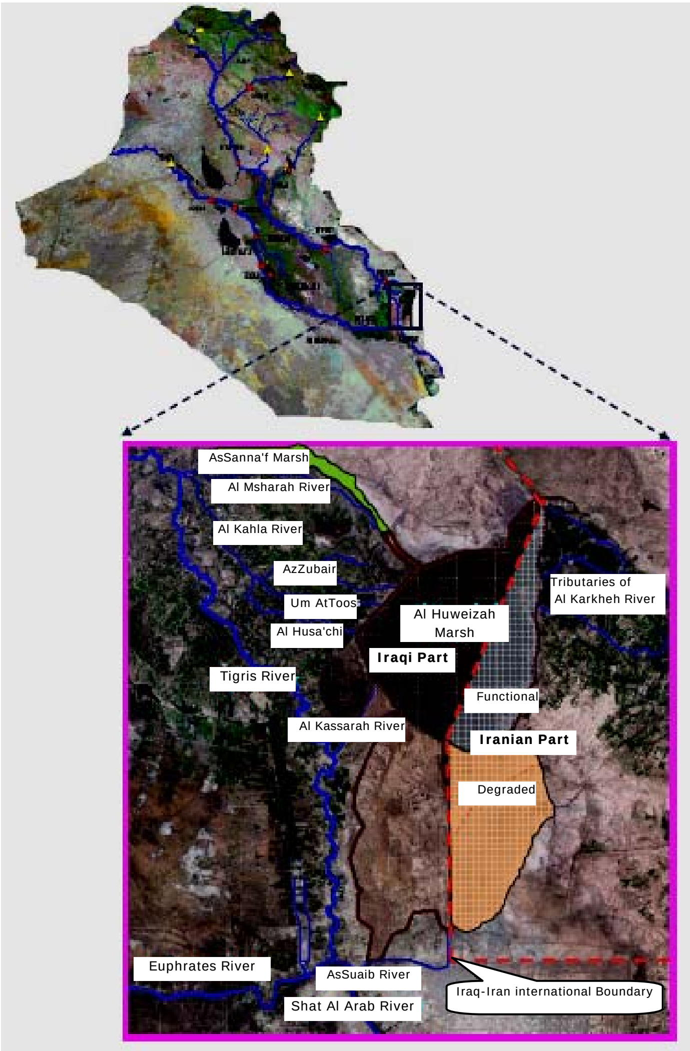

Fig. 1 : Location and Physiography of Al Huweizah Marsh.

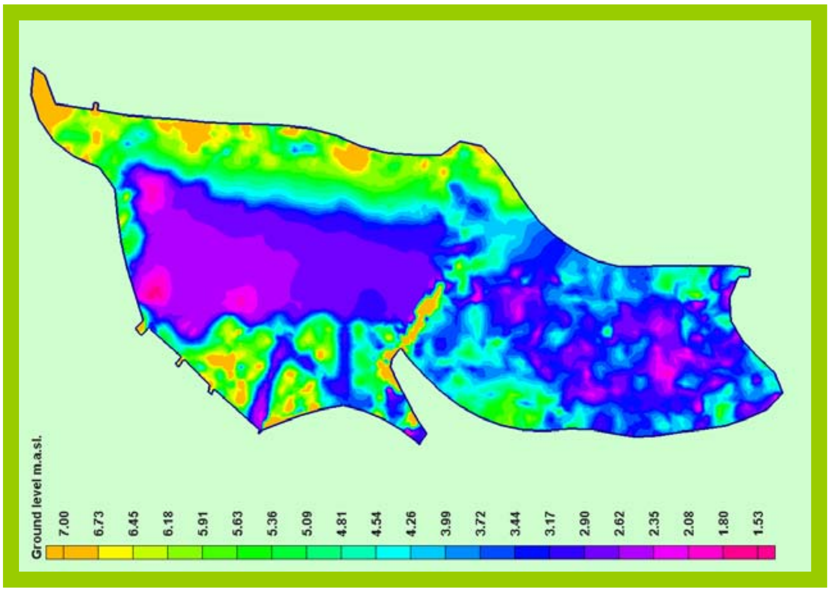

Fig. 2. DEM of the marsh

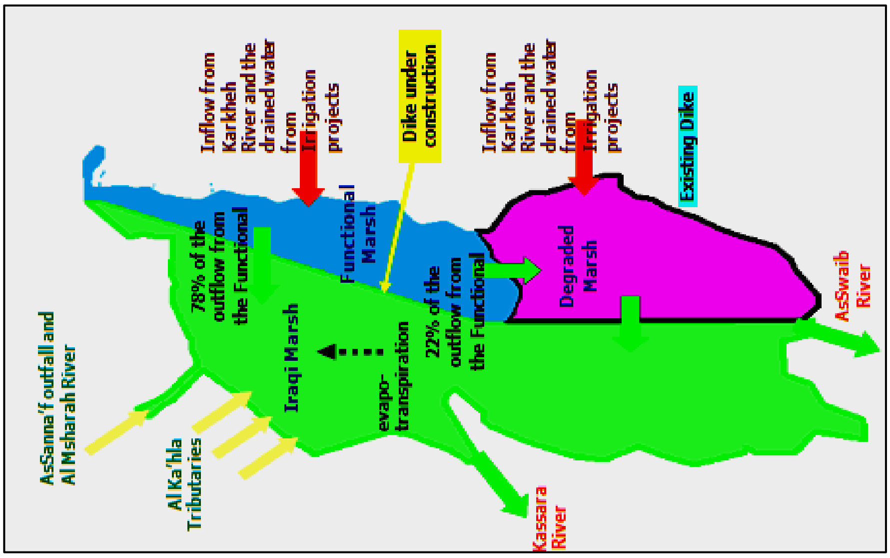

Fig. 3. Schematic diagram for the hydrological interference.

Fig. 4. Classification of the soils within the marsh area.

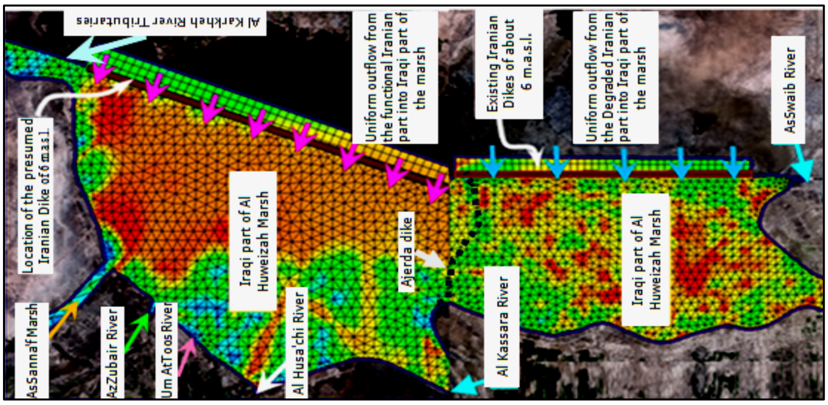

Fig. 5. The inflow from Iranian part into the Iraqi part of the marsh.

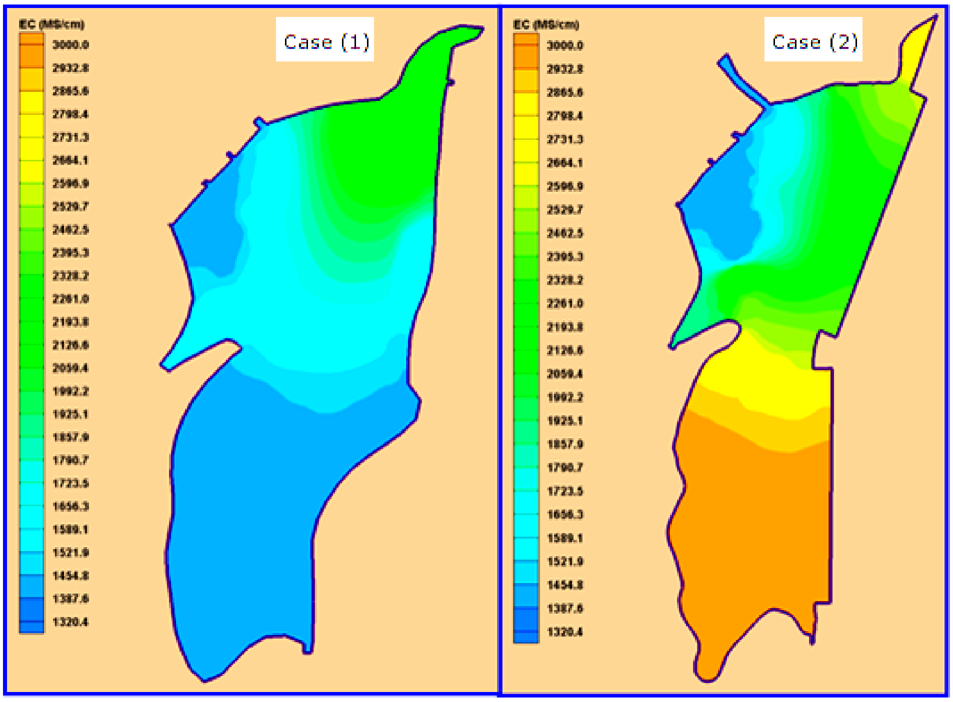

Fig. (6). Distribution of during autumn for wet year.

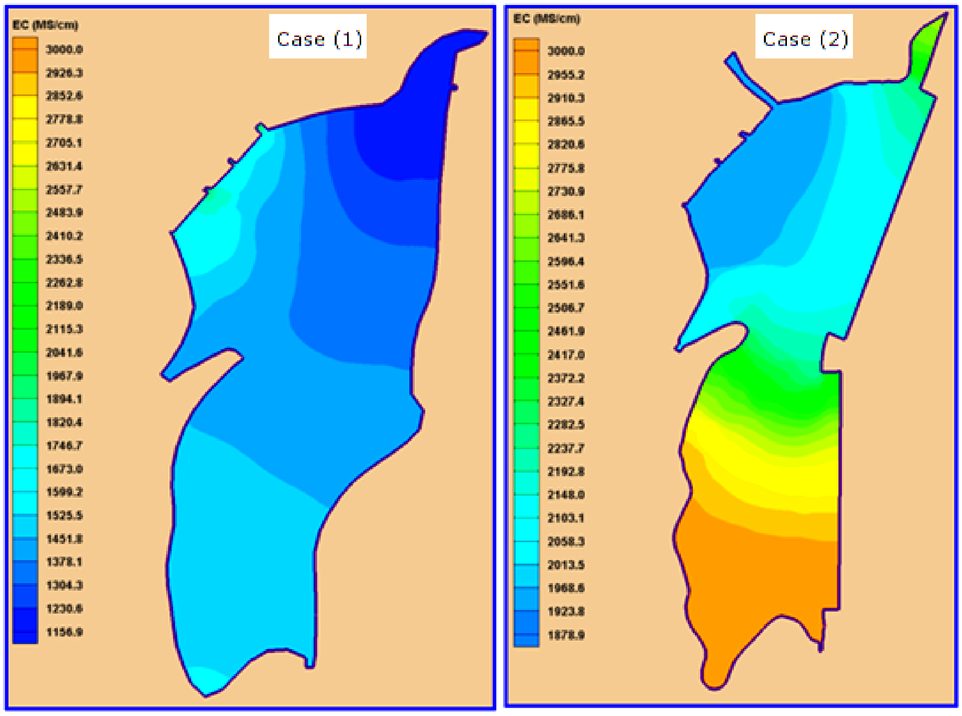

Fig. 7. Distribution of EC during winter for wet year.

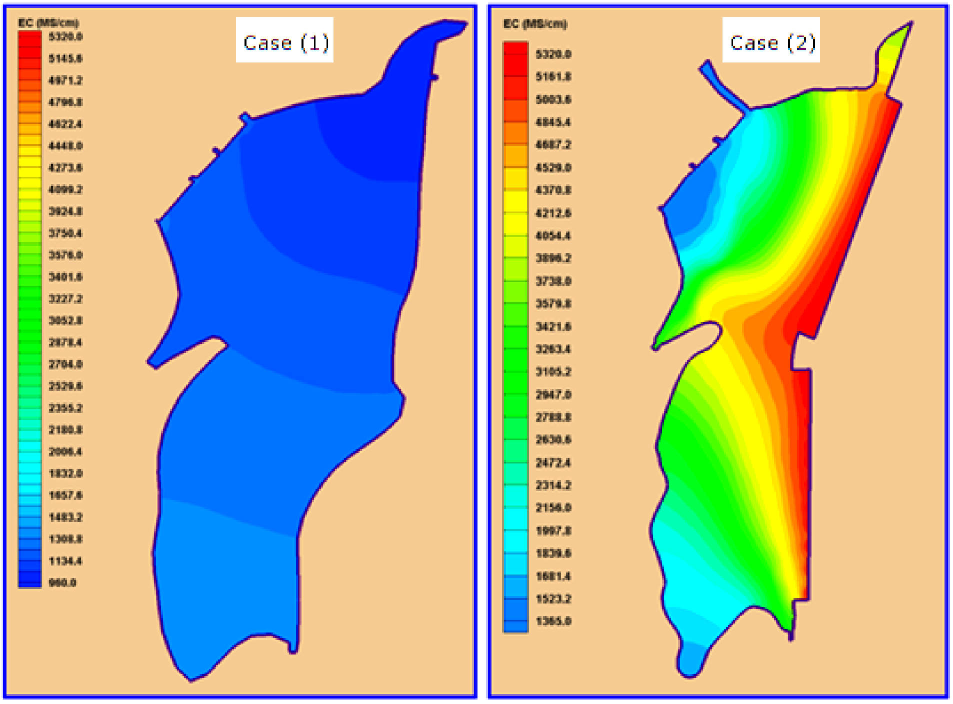

Fig. 8. Distribution of EC during spring for wet year.

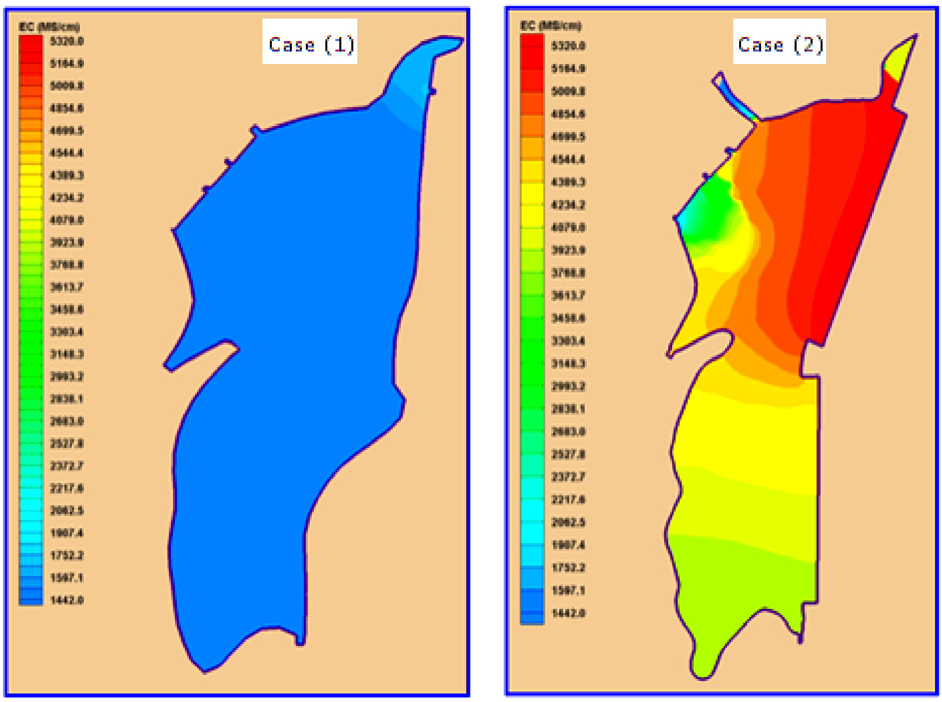

Fig. 9. Distribution of EC during summer for wet year.

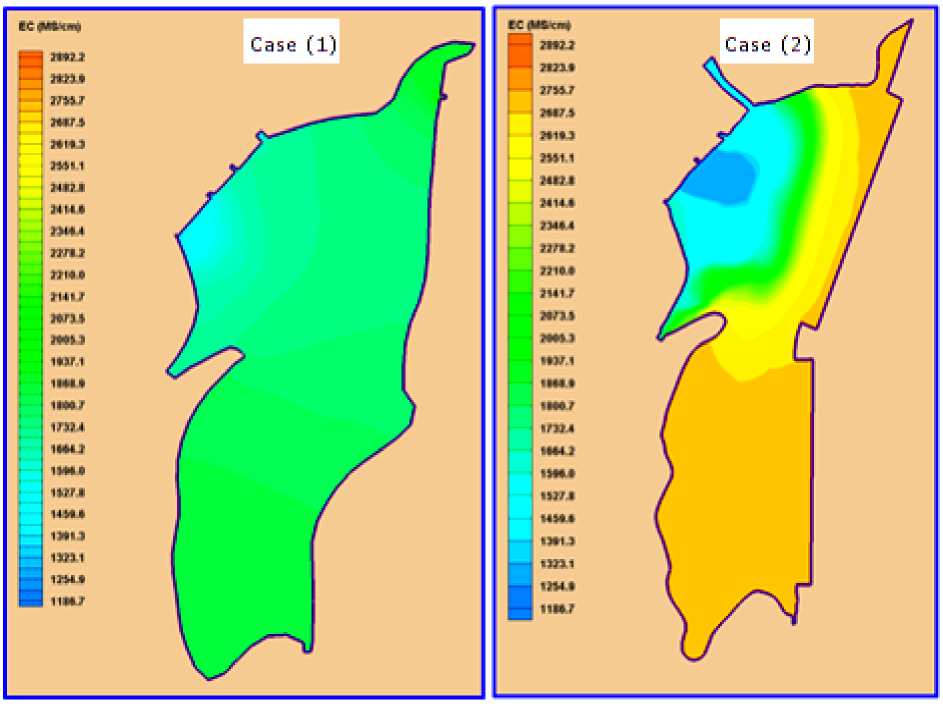

Fig. 10. Distribution of EC during autumn for moderate year.

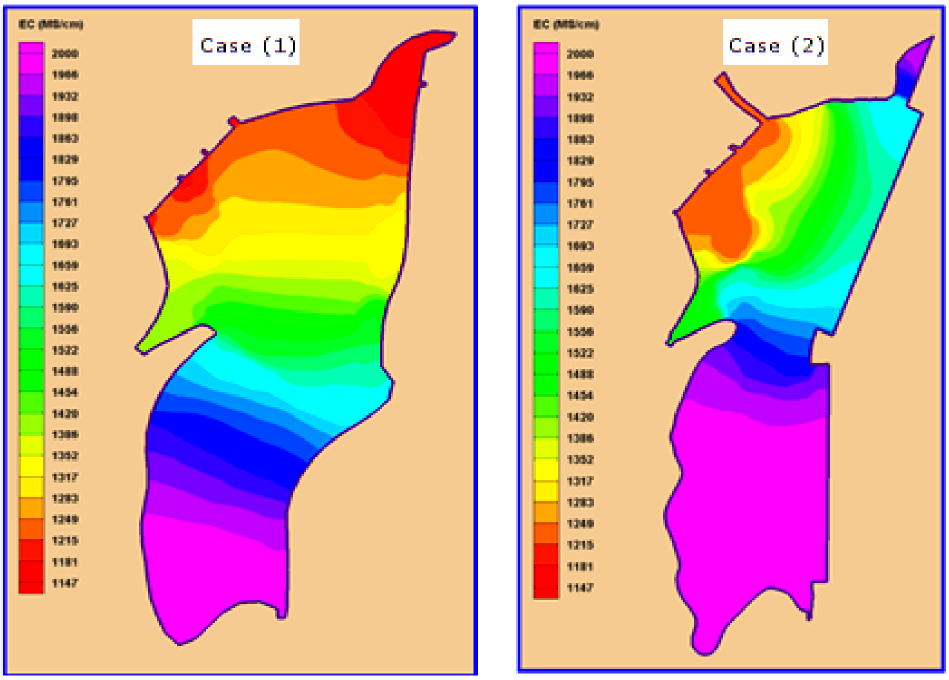

Fig. 11. Distribution of EC during winter for moderate year.

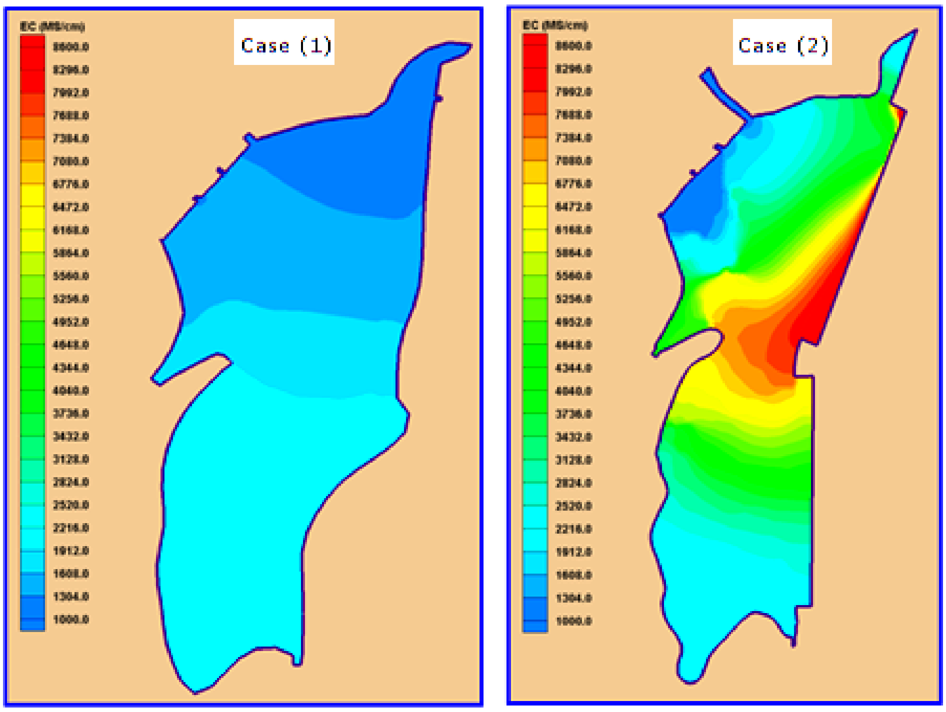

Fig. 12. Distribution of EC during spring for moderate year.

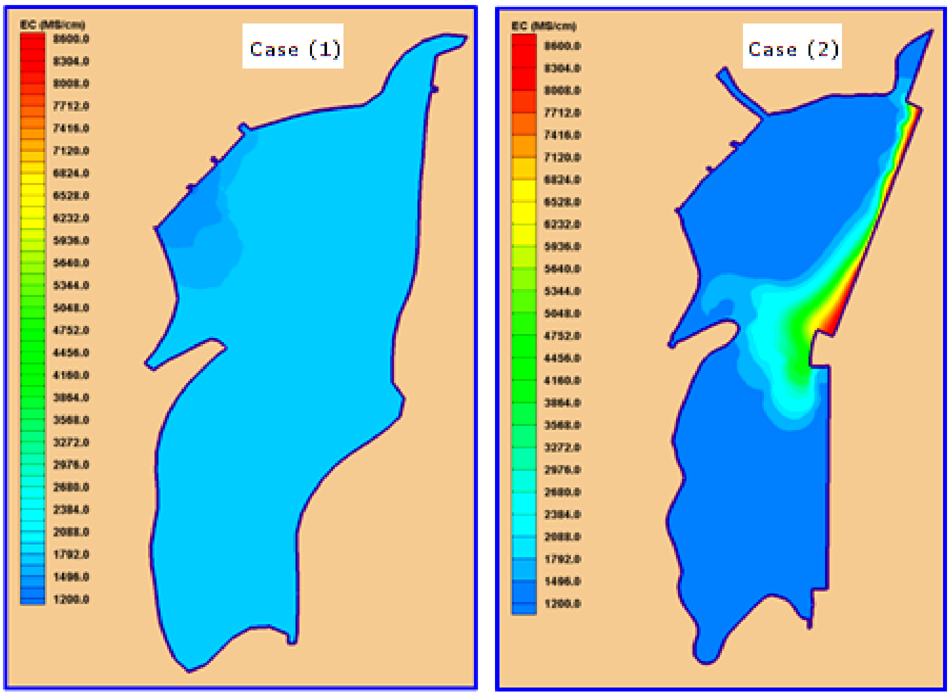

Fig. 13. Distribution of EC during summer for moderate year.

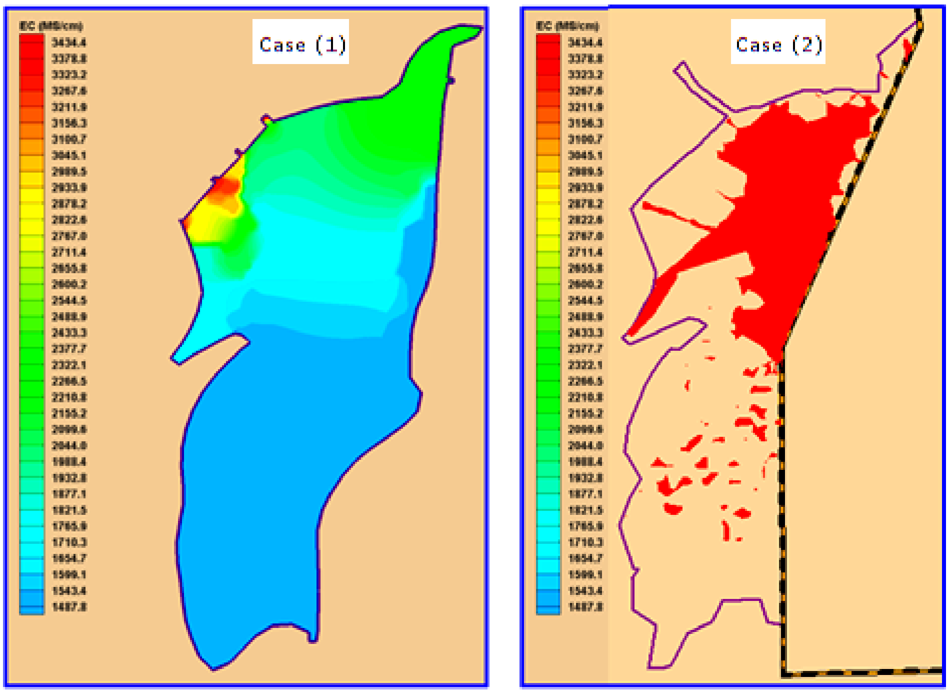

Fig. 14. Distribution of EC during autumn for dry year.

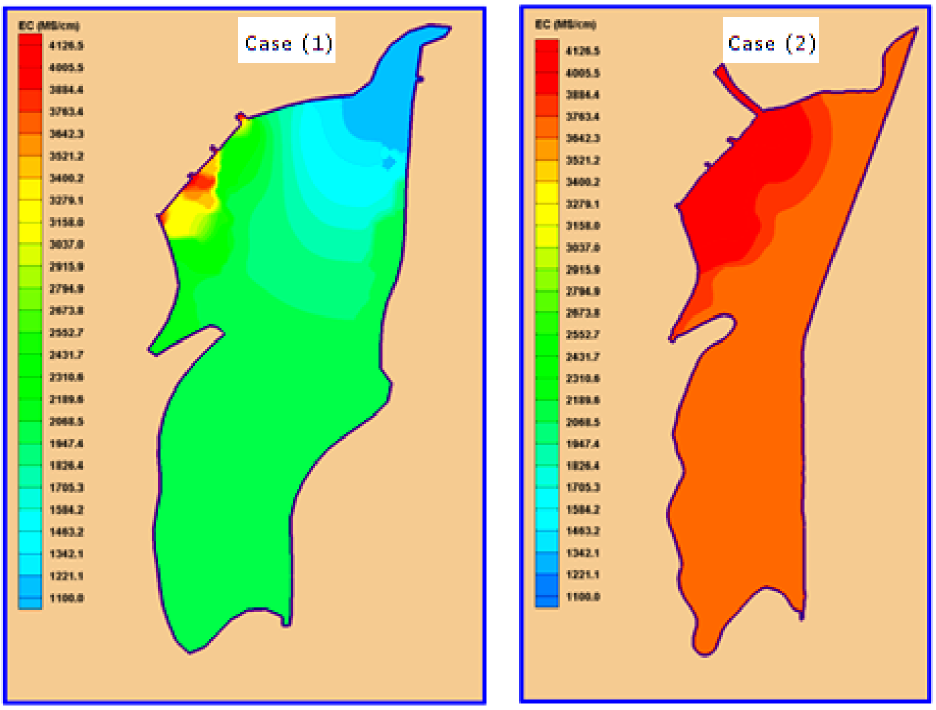

Fig.15. Distribution of EC during winter for dry year.

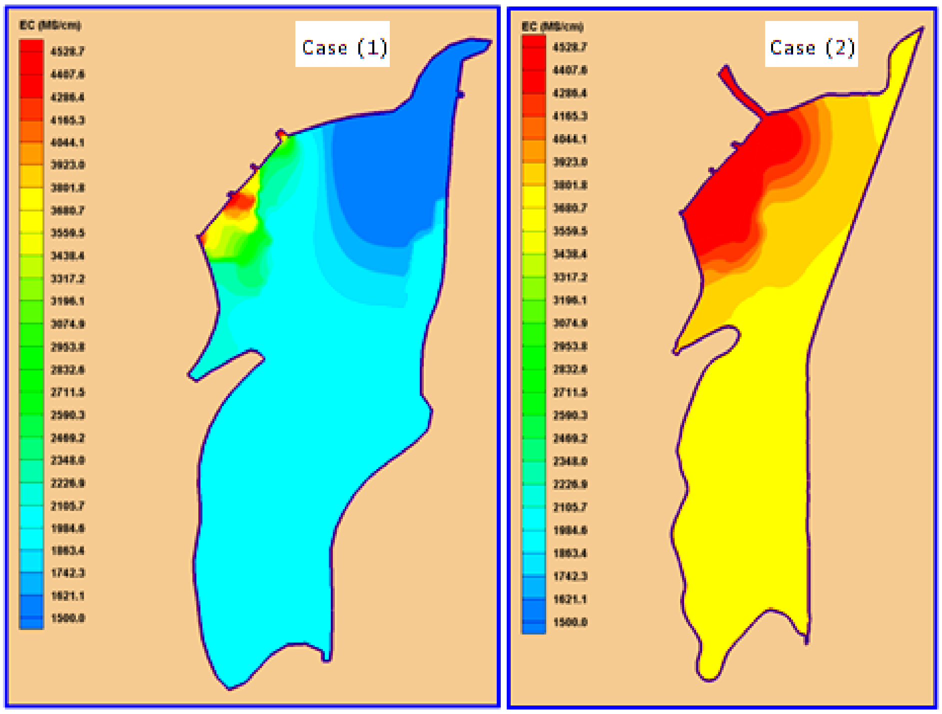

Fig. 16. Distribution of EC during spring for dry year.

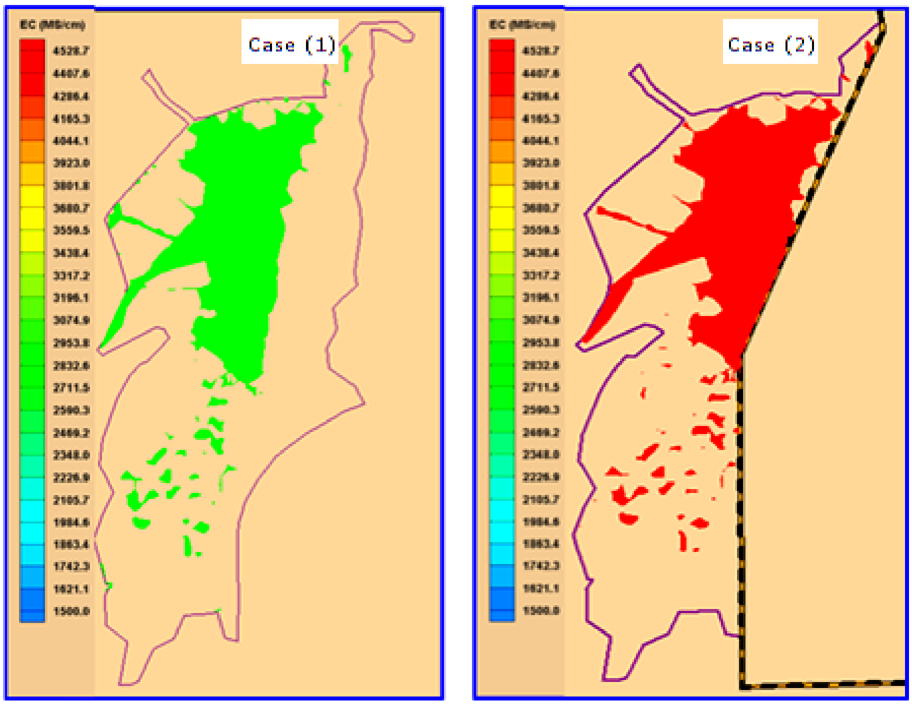

Fig. 17. Distribution of EC during summer for dry year.