

PREDICTION OF PHYSICAL AND CHEMICAL PROPERTIES OF IRAQI MARSH WATER USING GIS MODEL

**MOHAMMED D. SALMAN¹, MOURTADHA S. SATCHET¹ AND
WISAM J. KHUDHAYER²**

¹College of Engineering, University of ThiQar, ThiQar 64001, Iraq

²Department of Energy Engineering, University of Babylon, Babylon 51002, Iraq

Abstract

In this work, a geographical international system (GIS) model is designed to predict the physical and chemical concentrations in marsh water. Samples are selected from seven sites to analyze the marsh water quality based on sixteen parameters including physical properties: total dissolved solids (TDS) and electrical conductivity (E_c) and Chemical properties: the acidity (pH), calcium concentration (Ca), magnesium concentration (Mg), chloride concentration (Cl), sulphate concentration (SO_4), ammonium (NH_4), nitrite (NO_3), potassium (K), heavy metals (Cu, Cr, Ni, Mn, and Zn), and dissolve oxygen (DO). The measured data are utilized to build the GIS model. Eventually the developed model is used to predict the targeted properties in randomly selected- sites and compare them with the measured data. The comparison shows a good agreement between the predicted and measured data. The GIS model gives an overview about the distribution of these parameters on the marsh areas, which in turn helps in evaluating the pollution in marsh water. This may assist in suggesting the treatment points in this area and can provide the decision-makers with a scientific evidence to optimize the related emergency response measures.

1. INTRODUCTION

The quality of water at the present time is important and fundamental that must be taken care of because of their close relationship in various uses, including agricultural, drinking, industrial and animal uses⁽¹⁾, as well as for use in nutrition and rehabilitation of the marshes. These imperatives take its importance at the present time in Iraq because of the scarcity of

current revenue water, poor quality resulting from the control of the upper basin water resources and not to give Iraq its share of assessments of the water, the problems of drought and global warming⁽²⁾. This is in addition to the growing demand for water as a result to increase the rates of population growth and development of agricultural activities and economic and social development.

Iraqi marshes are one of the most ancient marshes in the world and pride themselves on its beautiful scenery and its rich natural ecological system. Closely involved in the lives of people over many years, marshes have been an important water resource and helped create and preserve distinctive culture. Lack of water resources and optimum management have been two recent challenges of water resources engineering⁽³⁾. Population growth, decrease of useable water resources, improvements in lifestyle, growing rate of consumption, climate change, and several other parameters have caused useable water to be a significant problem for future. Economic and efficient use of water resources and its management have an increasingly significant role⁽⁴⁾.

A geographical information system (GIS) is a tool that can help the decision makers in having a better understanding of the changes, which may take place in a region of interest. The GIS has the following advantages: capable of utilizing different types of spatial data by analyzing and presenting them on maps, developing solutions for water resources problems, determining availability of water, assessing water quality, preventing flooding, and the ability to accommodate satellite or “space-based” data.⁽⁵⁻⁹⁾ These “space-based” data have been coupled with data from other sources to observe changes in the Marshes and assess how various development activities influence the wetlands extent and health. This research adopted the prediction of physical and chemical properties using GIS model .In this regards, a detailed study is carried out to have a good view for the changes in the physical and chemical properties of the marshes, which in turn helps to monitor the pollution in marsh water.

2. EXPERIMENTAL PROCEDURE

Sampling was done at open water and near the vegetation of the water bodies to assess their physical and chemical qualities during April, May, and July 2011. The selected sites are represented in Table 1. These sites have been chosen due to their good access to roads and they have been divided equally between the different marshes / governorates to give a good

understanding of the different marsh habitats. Figure 1 shows the selected sites on the map of ThiQar province. Water conductivity, Total Dissolved Solids, and pH were measured using multi parameter water quality sonde model (6820-25 M-O U.S.A). Dissolved oxygen was measured using dissolved oxygen meter. The cationic and anionic contents (Ec, TDS, Ca, Mg, K, NH₄, SO₄, Cl and NO₂) and trace elements(Cu, Zn, Cr, Mn, Ni) were measured using multi parameter model HI83200.

3. GEOGRAPHICAL INTERFACE SYSTEM (GIS) MODEL

Modeling of the water quality in the selected marsh water sites is presented using the geographical interface system (GIS).The measured data from these sites are listed in tables (2 - 7) and used to build the GIS model. The system allows users to manage information and display it visually so researchers and decision makers can better understand changes that may occur. In its simplest form, a GIS is essentially a smart map. Multiple layers of data can be placed “on top” of one another and then analyzed using spatial statistics.

Information is vital for decision-makers, especially when a system is under stress. The Southern Iraqi Marshes require constant monitoring as the system has undergone major changes. Information on water quality can be entered into the database and, if the location of sample sites is known, these data can be linked to specific locations. This allows the GIS user to make connections between the type of lands and the quality of water within the area of interest. The GIS is important because it can help predict and monitor drought, water quality issues, and possible land use conflicts along with any other major issue facing an area. ⁽⁵⁻⁹⁾ To utilize GIS as a decision-making aid, it is vital for all stakeholders to have access to information that is accurate and up-to-date.

When the GIS model was first being developed as it can be seen in figures (2) and (3), the data search were conducted and incorporated into the system. This information had to be entered into the system manually as a dynamic system, the marsh extent changes monthly ⁽⁶⁻⁷⁾.

4. RESULTS AND DISCUSSIONS

Physical and chemical properties in selected marsh water area are predicted using GIS model. Figures 4-9 show the distribution of cationic (Ca, Mg, and K), anionic (NH₄, SO₄, Cl and NO₂), and dissolved oxygen concentrations along the selected marsh area during April, May, and July 2011. The concentrations of Heavy metals (Cu, Zn, Cr, Mn, and Ni) are

determined experimentally and predicted by GIS model. During the emergency response of water pollution accidents, one may need to predict the change in pollutant concentrations over time in some important sections. Since the marsh water is divided into sections, the forecast of the concentration of pollutants in a section can be achieved by choosing the element, which represents the section, especially after restoration of marsh water by mixing Al masab Alaam drainage with Euphrates river as resources for feeding water to marsh water in southern of Iraq.

The GIS is a simple and effective tool to help decision-makers and local residents in planning for future activities in the Marshes. It is improving knowledge and understanding of the Marsh ecosystem; how it has changed over time, the degree of restoration of marsh water with any source, help decision-makers on present and future challenges within the Marshes, assisting communities in making choices for either protecting specific areas or allowing for development and/or expansion based on the water quality pollution degree of Marsh ecosystem, and allowing for the visualization of data and easy analysis within a relatively short time frame.

The developed GIS model is tested by creating maps which show the spatial variability of different water quality parameters as shown in Figs (10- 15). This is done by measuring the concentrations from sample points and comparing them with predicted data from GIS model, then computing the percentage deviation as shown in Fig. (16) and Table (8). The percentage deviation is calculated according to the equation:

$$\% \text{ deviation} = \frac{\text{Predicted Value} - \text{Field Value}}{\text{Predicted Value}}$$

Where the predicted value computed from GIS model and the field value measured from Marsh Site. It is shown that the deviation value is acceptable for all parameters except that for Zn and Ni. The relatively large deviation between the measured and predicted values of these heavy metals is strongly related with wastewater discharged to the stream and their concentrations from animal movement in the stream especially at these months such as buffalo. This in addition to the fact that the data may not reflect all ecosystems within the marshes (e.g. ground water interactions, fluctuations in water levels, status of rare and endangered species, etc.)

The GIS system appears to have immediate potential for operational use as a decision support tool for water management in the area. The developed system is expected to help the

decision maker to take the appropriate actions to improve the marsh water quality and therefore, the conservation of the marsh ecosystem.

CONCLUSIONS

This study shows that the GIS model presented good prediction to the distribution of physical and chemical properties of marsh water compared to the measured data. As a monitoring program, GIS is needed to give information for the possible occurrence of contamination in marsh water body and provide the effective action at all levels. It is an effective, cheaper, and valuable tool in monitoring water quality parameter in Marsh water body. The results reveal that the percentage deviation between the measured and predicted values is so small except that for (Ni and Zn). This research can be considered as a contribution to an ongoing effort to develop GIS model to solve the problems associated with unit design of water and wastewater treatment.

REFERENCES

- [1]. Kadhim A. J., "Water quality monitoring of Abu Zirig marsh in southern in Iraq (after drying)", M.Sc. thesis, Environmental Department / College of Engineering / Al-Mustansiriyah University (2005).
- [2]. Al-Hilli M.R., "Studies on the plantecology of the Ahwar region in Southern Iraq" Ph.D. Thesis , Cairo University, Egypt (1997).
- [3]. Al-saad H.T. and Mustafa Y.Z., "Pollutants in the sediment of Iraqi marshes: A review in Ahwar of Iraq Environmental Approach", Hussain, N.A., (ed). Marina Science Centre Publication, No.18. (1994).
- [4]. Hussein N. A., "Ahwar of Iraq Environmental approach" Seas Researches Center: Number 18, pp. 149 (1994).
- [5]. Ketata-Rokbani, M., Gueddari, M., and Bouhlila, R., "Use of Geographical Information System and Water Quality Index to Assess Groundwater Quality in El Khairat Deep Aquifer (Enfidha, Tunisian Sahel)", Iranica Journal of Energy & Environment 2 (2): 133-144, (2011).
- [6]. Shabbir, R., Ahmad, S. S., "Use of Geographic Information System and Water Quality Index to Assess Groundwater Quality in Rawalpindi and Islamabad", Arabian Journal for Science and Engineering, Volume 40, Issue 7, pp. 2033–2047, (July 2015).

[7]. Zheng, Z. M., Xia, B., Zhang, J.L., “Research and Practice on Integration of GIS and Water Quality Model. Environmental science and technology”, 28, pp.10-11 (2005).

[8]. Nag S.K., Saha S., "Integration of GIS and remote sensing in groundwater investigations: a case study in Gangajalghati Block, Bankura District, and West Bengal, India". Arab. J. Sci. Eng. 39 (7), 5543–5553 (2014).

[9]. Shomar B., Fakher S.A., and Yahya A., "Assessment of groundwater quality in the Gaza Strip, Palestine using GIS mapping", J. Water Resource. Prot. 2, 93–104 (2010).

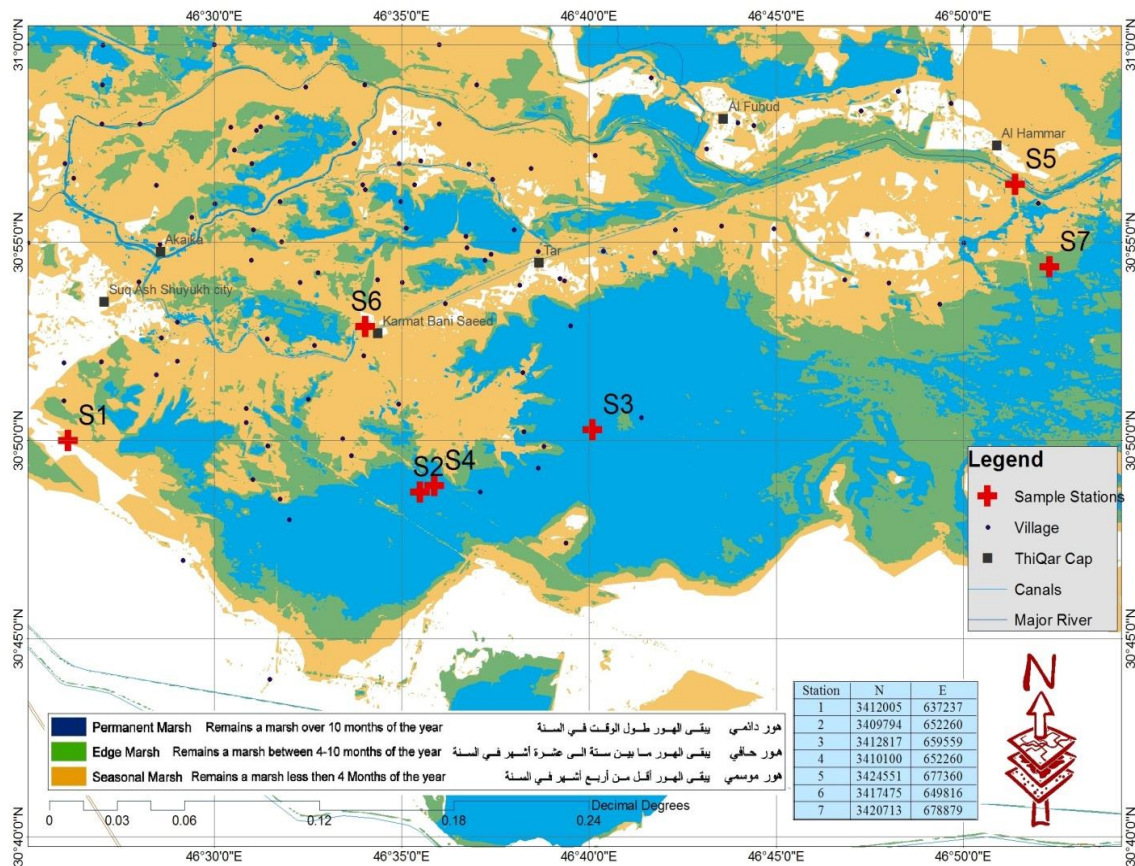


Figure (1) The distribution of the selected sites in marshes on the map of ThiQar province.

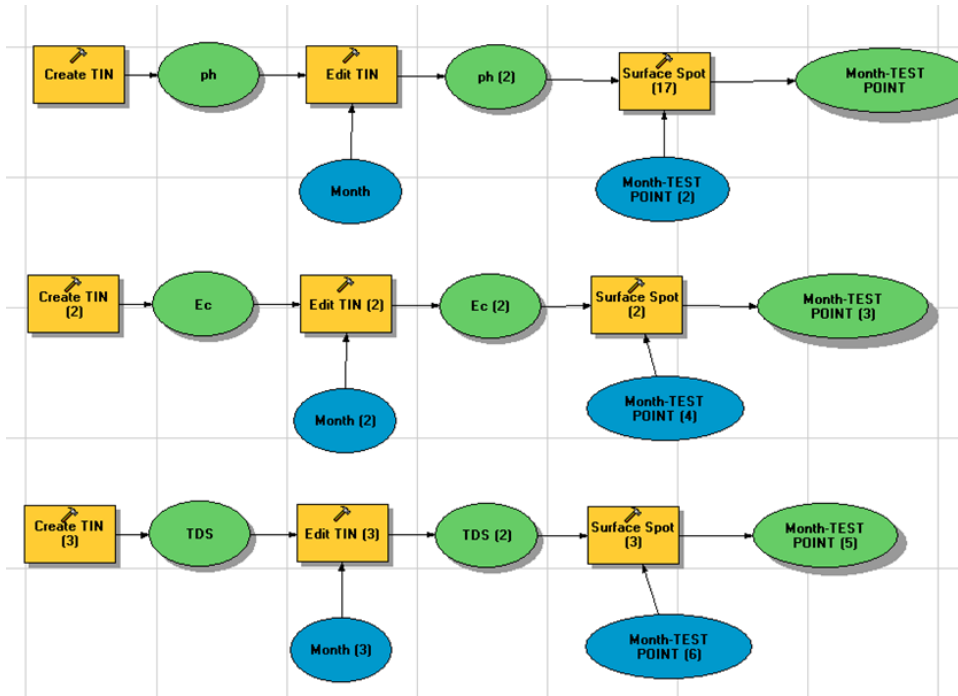


Figure (2) Diagram of GIS model

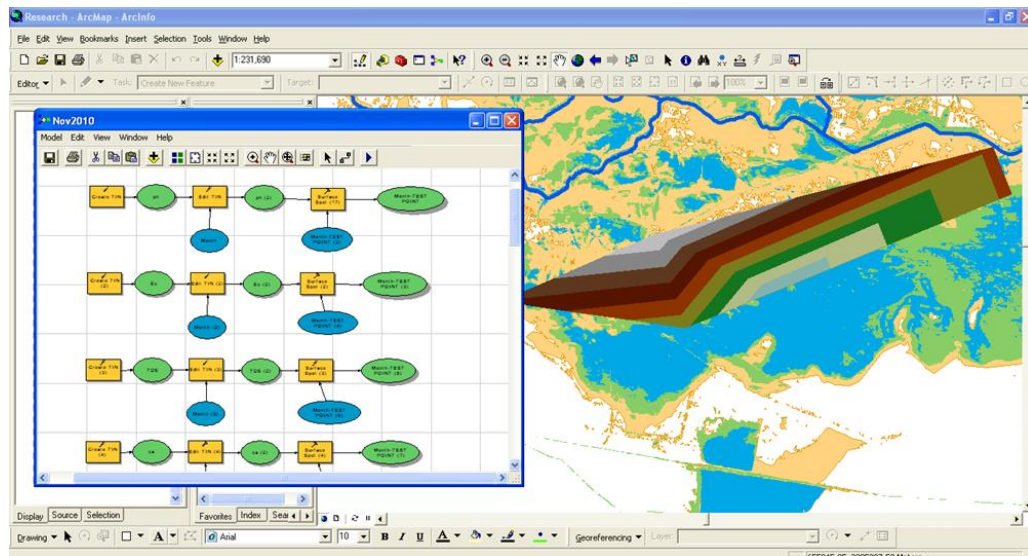


Figure (3) Map of the selected transects regions with its model.

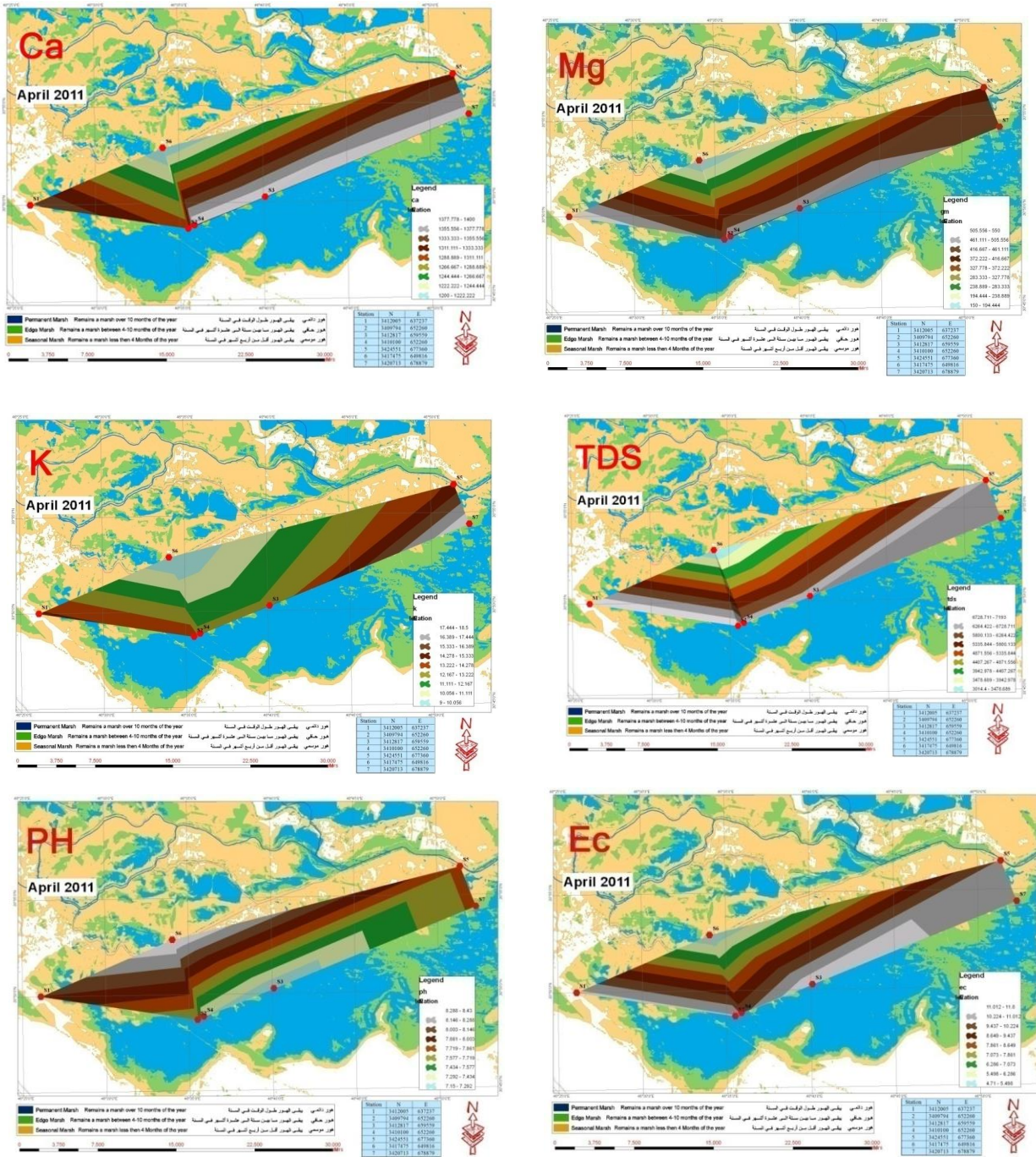


Figure (4) Distribution of pH, Ec and Cationic Concentration using GIS (April 2011)

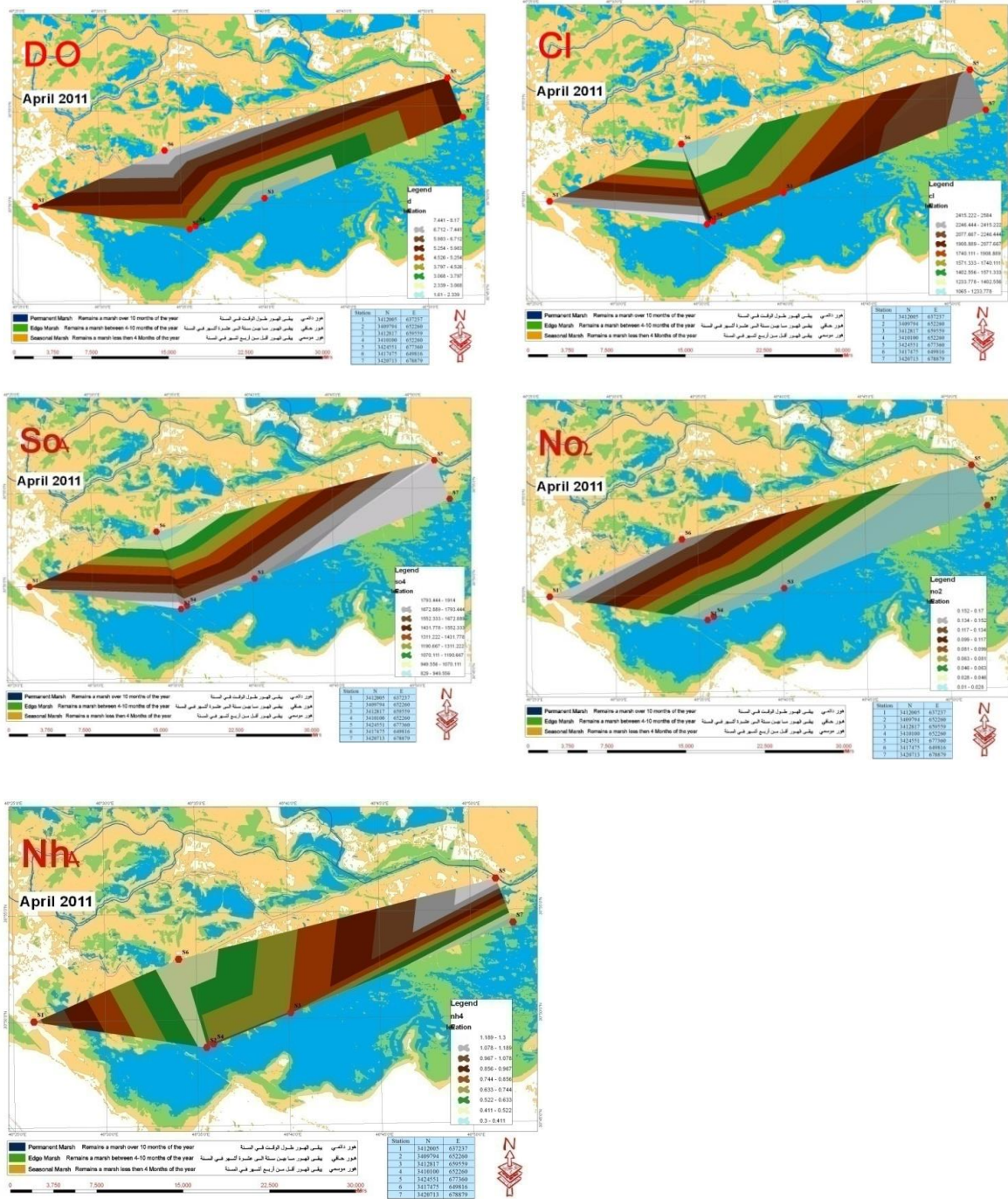


Figure (5) the Distribution of DO and anionic Concentrations using GIS (April 2011)

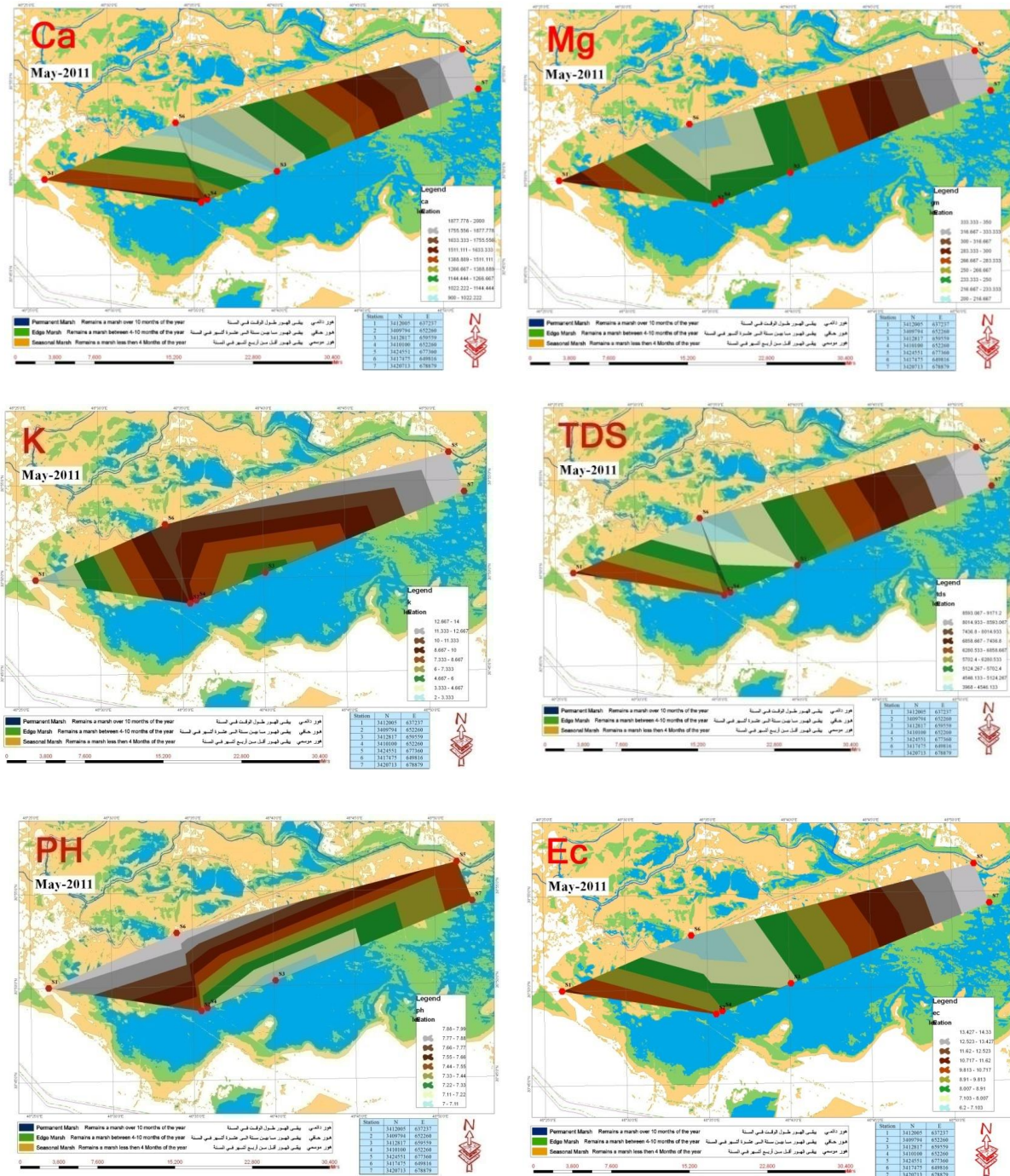


Figure (6) The Distribution of pH, Ec and Cationic Concentrations using GIS (May 2011).

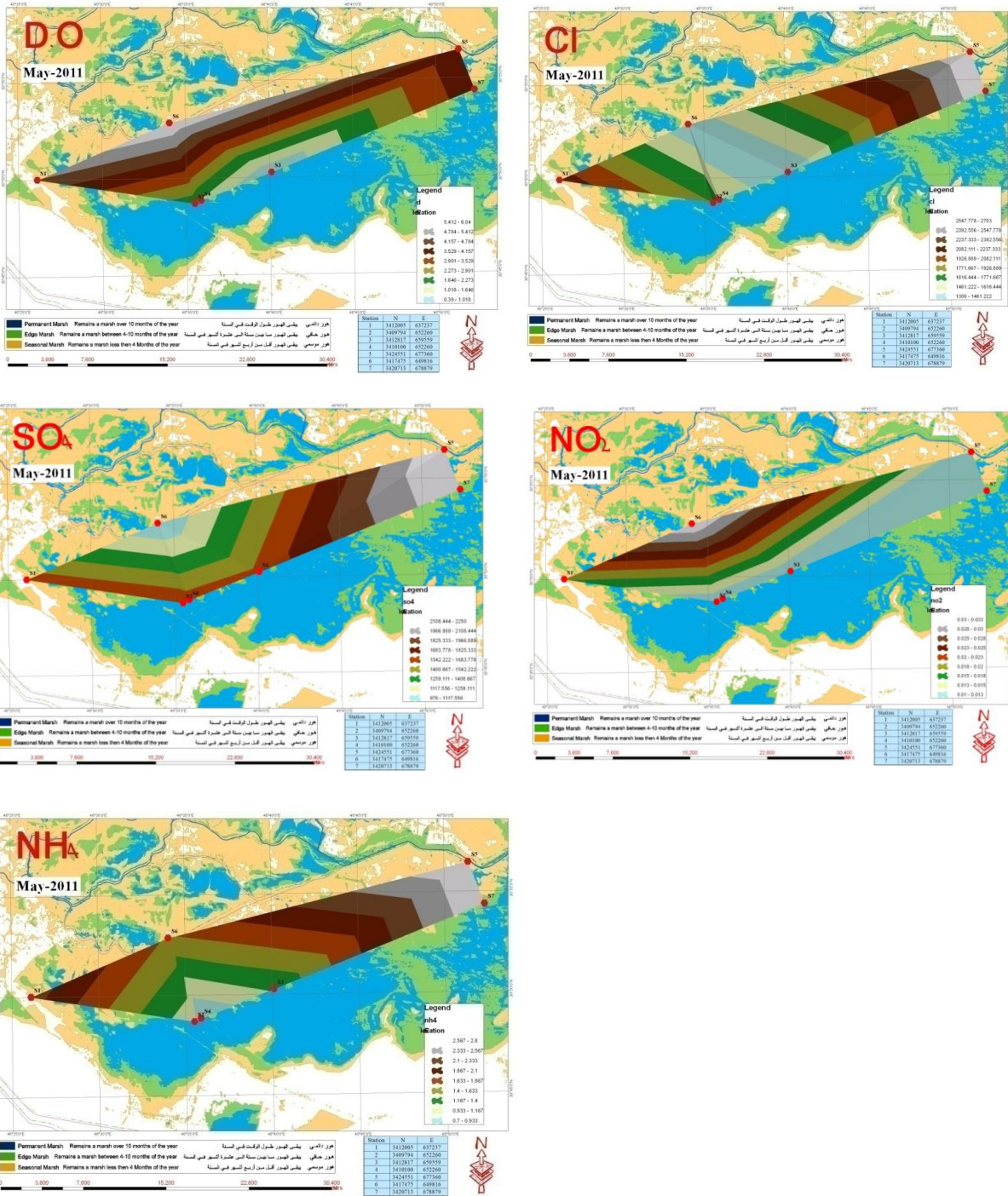


Figure (7) the Distribution of DO and anionic concentrations using GIS (May 2011).

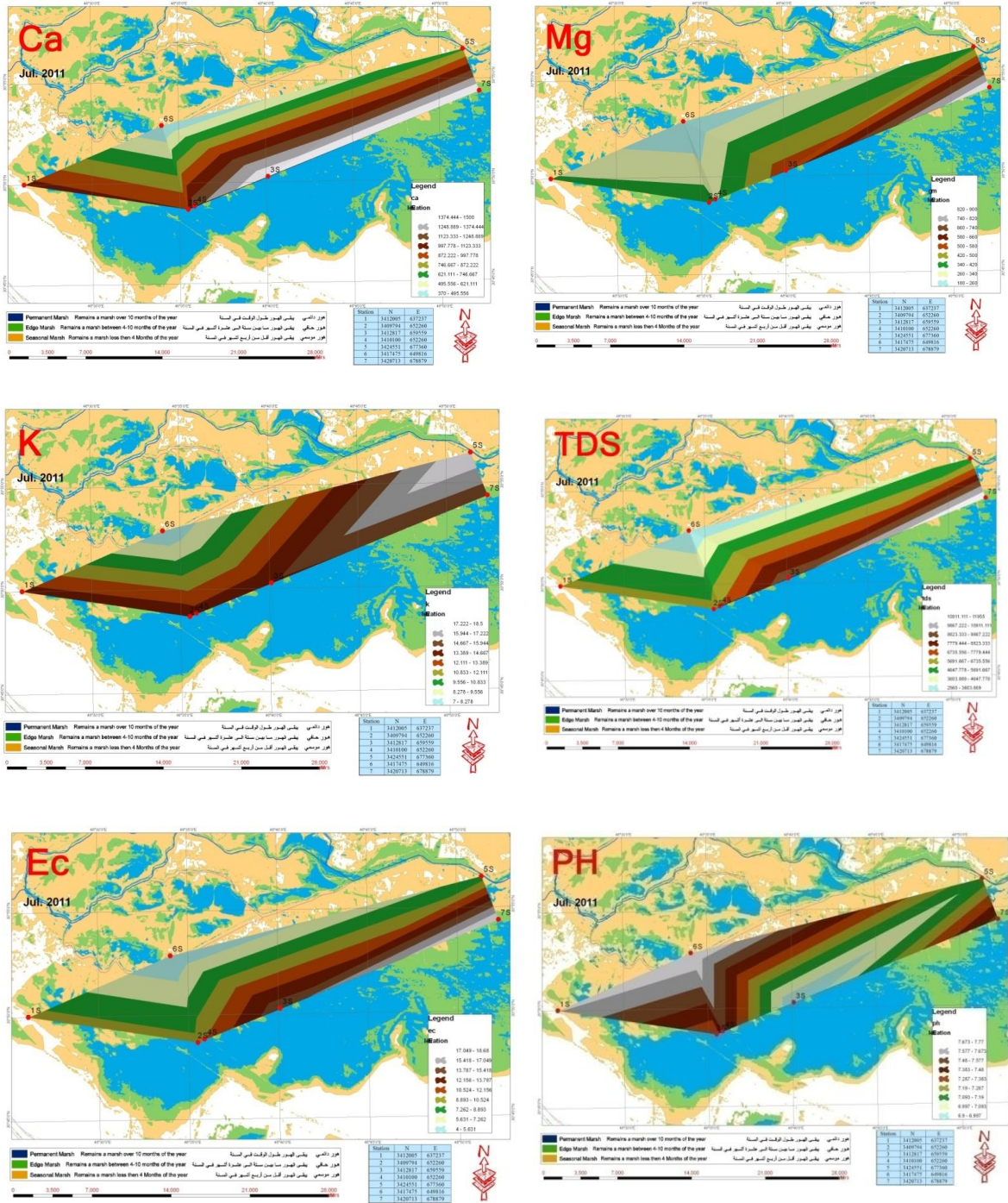


Figure (8) the Distribution of pH, Ec and Cationic Concentrations using GIS (July 2011)

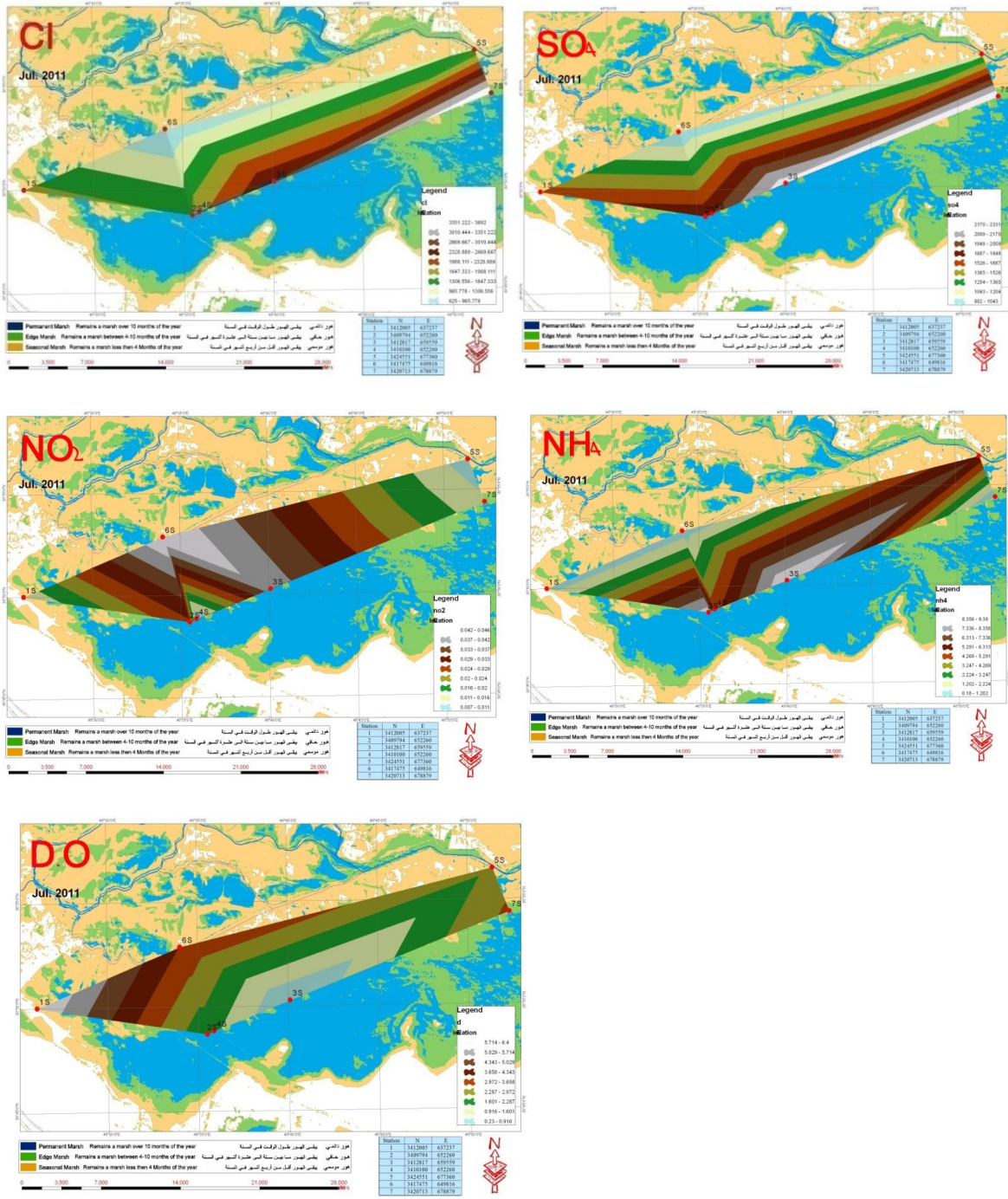


Figure (9) The distribution of DO and anionic concentrations using GIS (July 2011)

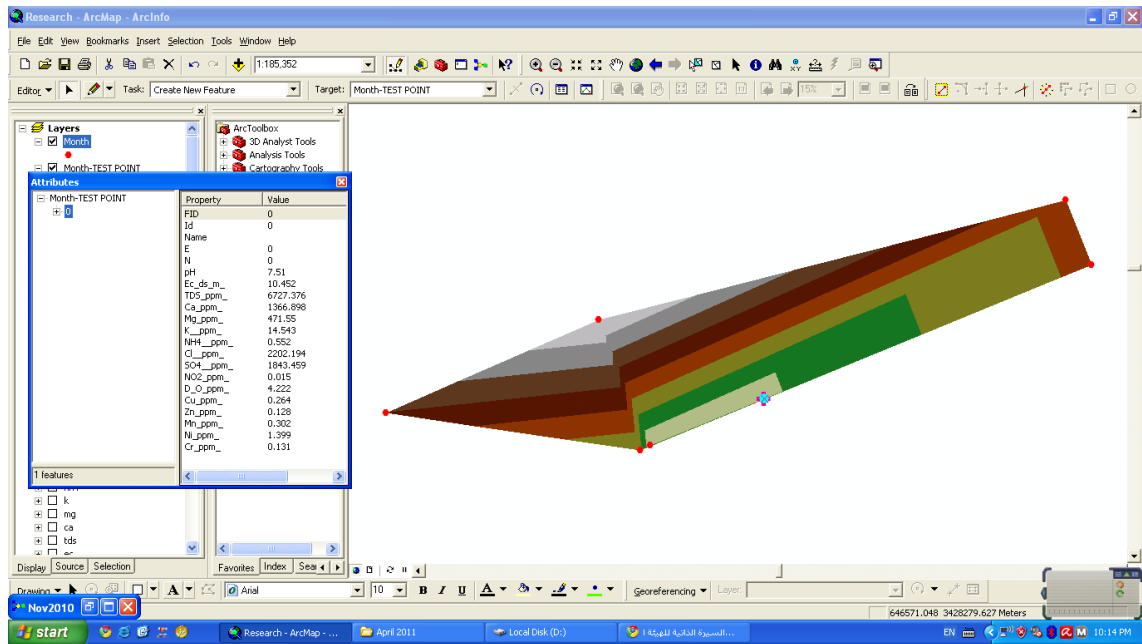


Figure (10) Tested GIS model for S3 sample data (April 2011)

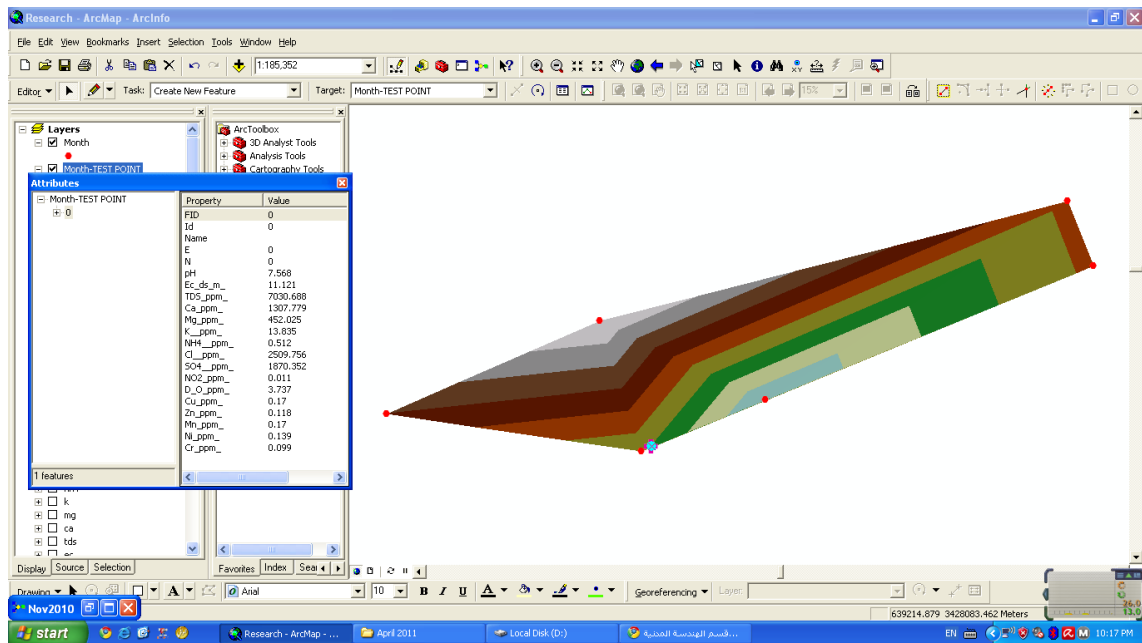


Figure (11) Tested GIS model for S4 sample data (April 2011)

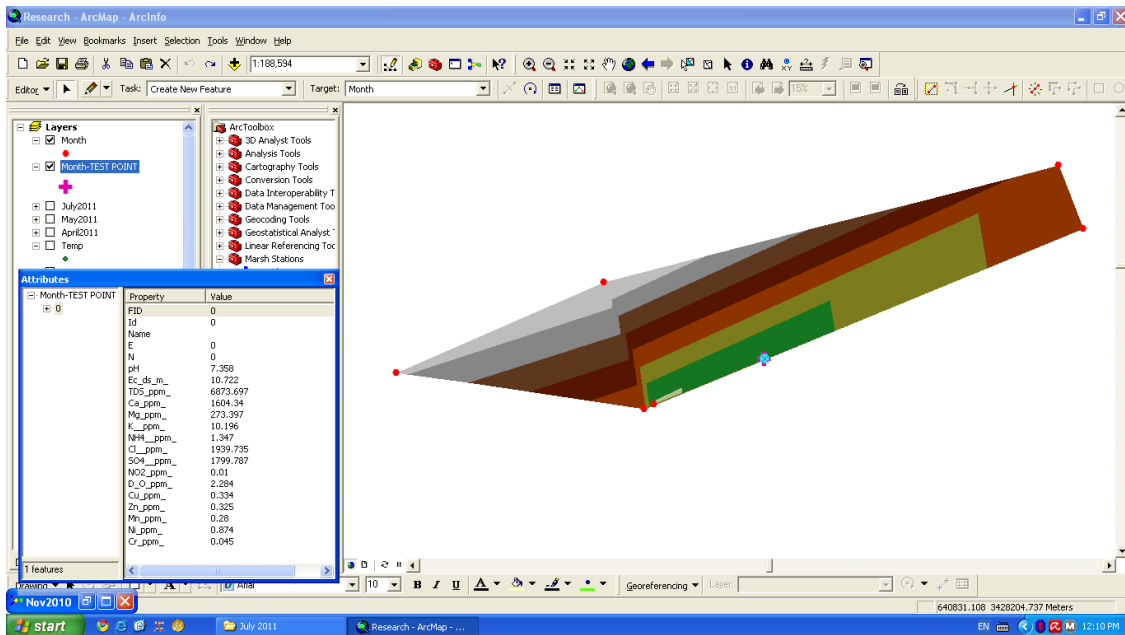


Figure (12) Tested GIS model for S3 sample data (May 2011)

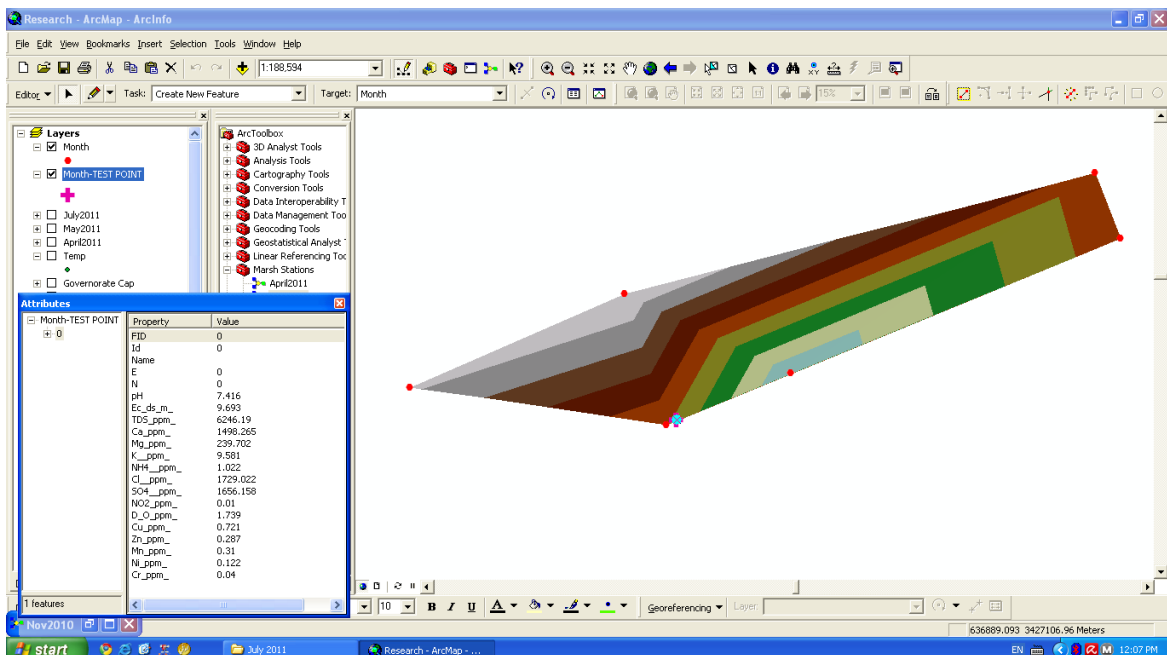


Figure (13) Tested GIS model for S4 sample data(May 2011)

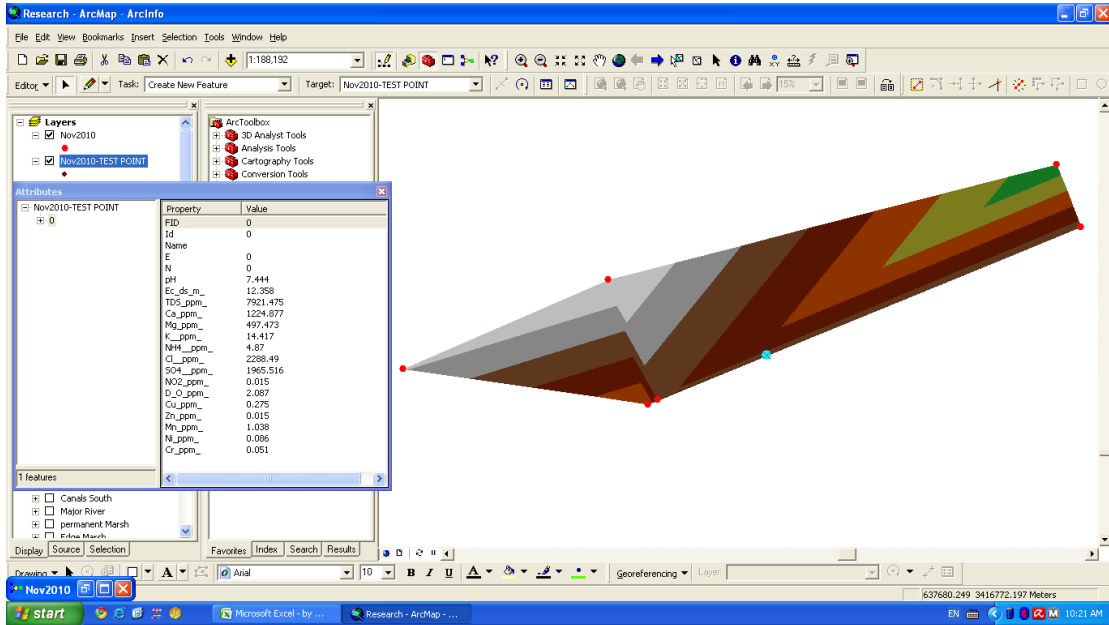


Figure (14) Tested GIS model for S3 sample data (July 2011)

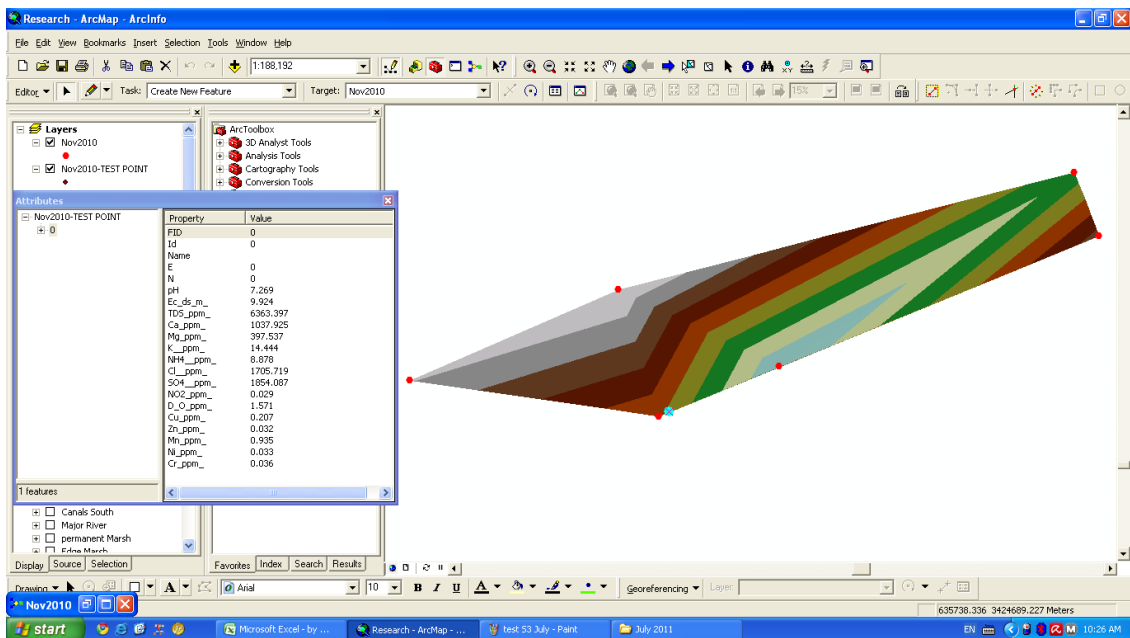


Figure (15) Tested GIS model for S4 sample data (May 2011)

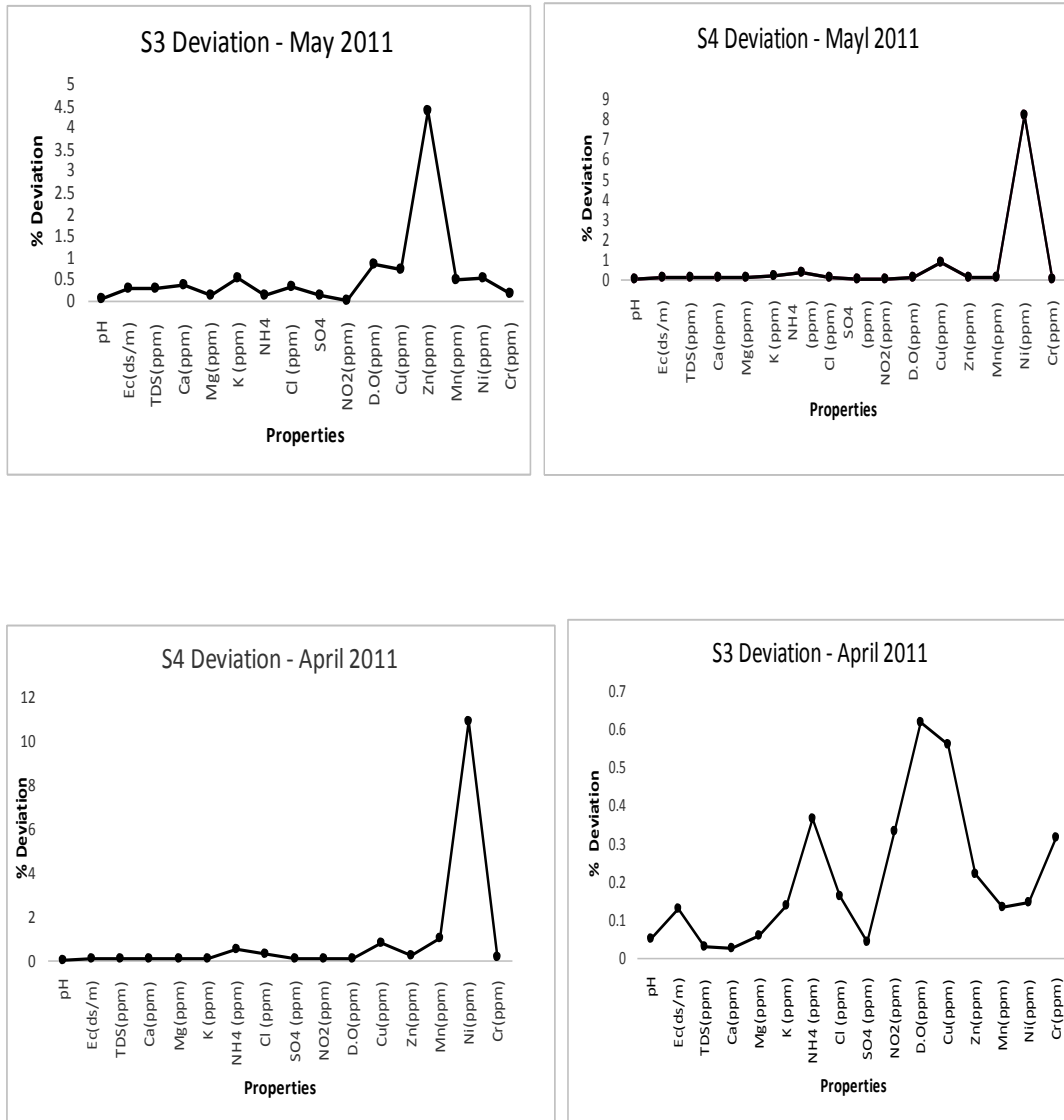


Figure (16) Deviations percentages Versus Properties (May and April 2011).

No.	Symbol	Coordinates	Sample Name
1	S1	38R0637237 Utm3412005	Al Masab Alaam (Drainage river)
2	S2	38R0652260 Utm3409794	Sunaf marsh (Kurmashia site)
3	S3	38R0659559 Utm3412817	Right Security barrier (Al Hemidi)
4	S ₄	38R0652260 Utm340979	Left Security barrier
5	S5	38r0677360 Utm3424551	Hamar Marsh
6	S6	38R0649816 UTM3417475	Euphrates river (Karmat bin Al saeed)
7	S7	38R0678879 UTM3420713	Hamar Marsh

Table (1) Symbols and coordinates of the selected sites.

Table (2) Anionic and cationic concentrations (April 2011)

D.O(ppm)	NO2(ppm)	SO4 (ppm)	Cl (ppm)	NH4 (ppm)	K (ppm)	Mg(ppm)	Ca(ppm)	TDS(ppm)	Ec(ds/m)	pH	Station
5.25	0.17	1648	2356	1.11	14.5	550	1360	7193	11.24	8	1
3.9	0.01	1889	2584	0.49	14	450	1300	7110	11.11	7.6	2
1.61	0.01	1763	1846	0.75	12.5	500	1400	6538	11.8	7.15	3
3.58	0.01	1768	1846	0.75	12.5	500	1400	6489	10	7.3	4
5.6	0.0125	1820	2272	1.3	14.5	400	1325	6600	10.3	7.75	5
8.17	0.15	829	1065	0.41	9	150	1200	3014.4	4.71	8.43	6
5.64	0.03	1914	2343	0.3	18.5	450	1390	6675.2	10.43	7.75	7

Table (3) heavy metals concentrations (April 2011)

Cr(ppm)	Ni(ppm)	Mn(ppm)	Zn(ppm)	Cu(ppm)	Station
0.05	1.95	0.46	0.049	0.068	1
0.1	0	0.15	0.12	0.148	2
0.09	1.6	0.342	0.1	0.412	3
0.087	1.65	0.339	0.14	0.308	4
0.23	2.6	0.416	0.115	0.32	5
0.096	0.287	0.601	0.069	0.134	6
0.237	2.6	0.416	0.117	0.326	7

Table (4) Anionic and cationic concentrations (May 2011)

D.O(ppm)	NO2(ppm)	SO4 (ppm)	Cl (ppm)	NH4 (ppm)	K (ppm)	Mg(ppm)	Ca(ppm)	TDS(ppm)	Ec(ds/m)	pH	Station
4.75	0.018	1622	2169	2.2	2	300	1500	6982	10.9	7.9	1
1.83	0.01	1669	1772	1	10	240	1550	6374.4	9.9	7.45	2
0.39	0.01	1579	1306	1.2	5	240	1000	5081	7.8	7	3
1.57	0.01	1616	1590	0.7	8	250	1400	5817	9.09	7.2	4
4	0.01	2250	2703	2.8	14	350	2000	9171	14.3	7.5	5
6.04	0.033	976	1336	1.6	11	200	900	3968	6.2	7.99	6
3.97	0.01	2250	2703	2.8	14	350	2000	9171.2	14.33	7.51	7

Table (5) heavy metals concentrations (May 2011)

Cr(ppm)	Ni(ppm)	Mn(ppm)	Zn(ppm)	Cu(ppm)	Station
0.045	0.025	0.315	0.431	0.268	1
0.04	0.01	0.3	0.15	0.78	2
0.037	1.31	0.417	1.75	0.09	3
0.04	1.12	0.33	0.27	0.134	4
0.058	1.47	0.176	0.615	0.147	5
0.05	0.201	0.347	0.185	0.692	6
0.058	1.47	0.174	0.617	0.147	7

Table (6) Anionic and cationic concentrations (July 2011)

D.O(ppm)	NO ₂ (ppm)	SO ₄ (ppm)	Cl (ppm)	NH ₄ (ppm)	K (ppm)	Mg(ppm)	Ca(ppm)	TDS(ppm)	Ec(ds/m)	pH	Station
6.4	0.012	1585	1738	0.65	14	350	1050	6112	9.55	7.68	1
1.68	0.028	1823	1624	8.9	14.5	385	1000	6093	9.5	7.3	2
0.23	0.04	2270	2670	9.38	14.5	550	1500	9574	14.95	6.9	3
1.74	0.007	1842	1897	4.9	14	330	1215	6739	10.5	7.5	4
2.43	0.009	1141	1363	6.16	18.5	390	720	4966	7.76	7.12	5
3.63	0.046	882	625	0.51	7	180	370	2560	4	7.77	6
3.12	0.012	2331	3692	0.18	15	900	1500	11955	18.68	7.52	7

Table (7) heavy metals concentrations (July 2011)

Cr(ppm)	Ni(ppm)	Mn(ppm)	Zn(ppm)	Cu(ppm)	Station
0.04	0.06	0.93	0.076	0.18	1
0.036	0.03	0.9	0.02	0.213	2
0.04	0.07	1.3	0.15	0.15	3
0.036	0.05	1.08	0.02	0.2	4
0.043	0.22	0.5	0.02	0.31	5
0.051	0.04	1.07	0.089	0.18	6
0.092	0.2	1.13	0.002	0.47	7

Table (8) Deviation percentage of physical and chemical properties from GIS Model (July 2011)

Cl (ppm)	NH4 (ppm)	K (ppm)	Mg(ppm)	Ca(ppm)	TDS(ppm)	Ec(ds/m)	pH	Station
2670	9.38	14.5	550	1500	9574	14.95	6.9	Measurement FieldS3
2288	4.87	14.417	479	1225	7921	12.358	7.44	Predicted GIS S3
0.166958	0.926078	0.005757	0.148225	0.22449	0.208686	0.209743	0.072581	% Deviation

Cr(ppm)	Ni(ppm)	Mn(ppm)	Zn(ppm)	Cu(ppm)	D.O(ppm)	NO2(ppm)	SO4 (ppm)	Cl (ppm)	Station
0.04	0.07	1.3	0.15	0.15	0.23	0.04	2270	2670	Measurement FieldS3
0.051	0.086	1.038	0.015	0.275	2.087	0.015	1965	2288	Predicted GIS S3
0.215686	0.186047	0.252408	9	0.454545	0.889794	1.6666667	0.155216	0.166958	% Deviation

NH4 (ppm)	K (ppm)	Mg(ppm)	Ca(ppm)	TDS(ppm)	Ec(ds/m)	pH	Station
4.9	14	330	1215	6739	10.5	7.5	Measurement FieldS4
8.878	14.44	397	1038	6363	9.924	7.269	Predicted GIS S4
0.448074	0.030471	0.168766	0.17052	0.059092	0.058041	0.031779	% Deviation

Cr(ppm)	Ni(ppm)	Mn(ppm)	Zn(ppm)	Cu(ppm)	D.O(ppm)	NO2(ppm)	SO4 (ppm)	Cl (ppm)	Station
0.036	0.05	1.08	0.02	0.2	1.74	0.007	1842	1897	Measurement FieldS4
0.036	0.033	0.935	0.032	0.207	1.571	0.029	1854.087	1705.72	Predicted GIS S4
0	0.515152	0.15508	0.375	0.033816	0.107575	0.7586207	0.006519	0.11214	% Deviation