Using GIS Technique for evaluating water quality of Abu Zarag marsh during the flood season

Ahmed Zamel Hassan¹ and Assist. Prof. Dr. Nawar O.A. Al-Musawi²

¹²Civil Engineering Dept., University of Baghdad/Iraq
Email: nawar.o@coeng.uobaghdad.edu.iq

Abstract
This research deals with the most important heritage in Iraq, which are the Iraqi marshes, especially Abu Zarag marsh in Al-Nasiriyah city south of Iraq. The research is divided into two parts. The first part deals with evaluating the water quality parameters of Abu Zarag marsh for the period from December 2018 to April 2019 which is the flooding season. The parameters are Temperature, pH, Electrical Conductivity, Total Dissolved Solids, Alkalinity, Total Hardness, Turbidity, Dissolved Oxygen, Sulfate, Nitrate. The second part is a comparison between the water quality parameters during the recent period with the same period during the previous years from 2014 to 2019. The results are represented in Arc GIS map. Modeling and simulation of flooding were made during the study period through the Arc GIS-Arc Scene program. The results of the research indicated the refilling of the Iraqi marshes especially Abu Zarag marsh, and recovery of the natural ambient in the south of Iraq.

Keywords
Abu Zarag Marsh, water quality, Water Resources of Iraq, Arc GIS-Arc Scene.

1. Introduction
The Iraqi marshes are known as New Eden, and they have been the cradle of Western civilization [1]. The Mesopotamian marshes are one of the largest water bodies in the Middle East and occupy wide areas of southern Iraq [2]. The Marshlands account about 17% of Iraq's area[3][4]. Marshlands are formed in the south of The Tigris and The Euphrates Rivers basin and their dependencies, extending from the north-east of Amara city to the north and Basra city to the south and al-Nasiriyah city to the west. These marshes are located between latitude 25°30' and 45°32' north and longitude 48°17' and 46°13' [5][6]. The central marshes were listed in the World Heritage List, especially Abu Zarag marsh [7]. The four natural components embrace significant cultural values, which complement the outstanding universal value of the cultural components. The Iraqi marshes extend through the four governorates of Al Basra, Maysan, Dhi Qar and Al Muthanna over a total area of 2,115,440,000 km² [8]

The characteristics of the population in Abu Zarag marsh are generally similar to those of the marsh population. Abu Zarag marsh is an integral part of the marshes in Dhi Qar province and occupies about 3% of the total area of Iraq's marshlands, which had a drought in 1991, as the rest of the central marshes. The water returned to this marsh after 2003 when the repayment was broken, and its opening was done where the water and life returned to this marsh. Abu Zarag is considered one of the first marshes where the water returned. This research deals with the flooding season
from December 2018 to April 2019, that caused refilling of Abu Zarag marsh and the surrounding marshes, and discusses the change in water quality parameters as a result of this flooding.

2. Title missing

2.1 Area Description:
The study was conducted on Abu Zarag Marsh in Dhi Qar Province in the area of Al-Salah and Panthers in southern Iraq. It is located around the cities of Al-Salah in the north with a population about 35,000 inhabitants and the city of Al-Fhood in the South with a population about 42,000 people. There are a number of residential communities, and villages spanning on the shores of the lagoon. The population depends on fishing, agriculture and breeding herds al-Buffalo, as well as making rugs and pipes of cane, which is known by all the Marsh people in Iraq. Abu Zarag marsh is situated in the south of Iraq, 200 km southeast of Baghdad. Nasiriyah is the largest nearby city as shown in figure 1.

![Figure 1: Location of Abu Zarag marsh [9]](image)

2.2 Methodology of Sampling:
Figure 2 shows the locations of sampling, where water samples from Abu Zarag marsh were collected from December 2018 to April 2019 in order to identify the water quality and discharge rates of Abu Zarag marsh. The samples were collected in polyethylene bottles with a capacity of 1.5 liters. The water was used for physical and chemical tests. It was filled with sample water before it was filled. The necessary information was recorded on each vial. Upon completion of the tests, the bottles were well washed and filled with distilled water until another sample is taken. Samples were kept at a temperature (4-10) C° for 24-hour, with reagent added to the sample to keep it from changes.
2.3 Ground Surface Elevation
Abu Zarag Marsh topographical survey data using the Digital Elevations (DEM), Google Earth and the Surfer 16 program, presented the topography of the region and the nature of the earth, as shown in figure 3.

3. Water quality during the period of study
3.1 Physical and chemical properties:
In order to summarize the quality of the water, the method of IDW in the GIS program was used to indicate the location of pollution of the marshes. Table 1 illustrates the water quality parameters to be measured:

| Standards | Type of examination (Variable) | Unit of Measure | The Global Standards | The Iraqi standards |
|-----------|---------------------------------|-----------------|----------------------|---------------------|
| temperature | C° | 13-35 | Less than 35 ° C |
| PH | - | 6.5 – 8.5 | 6.5 – 8.5 |
| E.C. | µs/cm | 2000 | 2000 |
| T.D.S. | ppm | 500 | Not more than 1500 |
| ALK | ppm | 1000 | Less than 17 |
| TH | ppm | 100-250 | 500 |
| NO₃ | ppm | 25-50 | 50 |
| SO₄ | ppm | 200-400 | 400 |
| Turbidity | NTU | 5 | 5 |
| DO | ppm | 5 | Greater than 5 |

**1-Temperature:** is a key determinant of the aquatic environment for all living organisms and any change in this factor from normal causes a change in the activity and effectiveness of living organisms. The heat also affects the speed of chemical reactions and the melting of gases that affect the taste and smell of water. The water temperature recorded in the study stations varied between the lowest value (14.1) °C during January, the highest value (20.8) °C during April. Figure 4a and Figure 4b indicate the impact of the water environment at ambient temperature recorded at the time of measurement and do not reflect the variance during the day. Most environmental indicators such as dissolved oxygen, other gases, ions, and salts are affected by changes in water temperature and the effectiveness of aquatic organisms. When comparing the temperature recorded during the study period, it was found to be identical to the Iraqi standards, which are less than 35 °C [13].

**Figure 4:** Spatiotemporal distribution of Temperature in Abu Zarag Marsh; a- Temporal variation, b- Spatial variation.

**2-pH:** The highest value of pH was in March (8.67) and the minimum value was in December (6.7), as shown in figure 5a and figure 5b. This range is acceptable, as it conforms to international and Iraqi
standards. The values recorded in the present study are consistent with many Iraqi studies that referred to the light water bases[14].

**Figure 5**: Spatiotemporal distribution of pH in Abu Zarag Marsh; a- Temporal variation, b- Spatial variation.

### Electrical Conductivity (EC)

Figure 6a and figure 6b show the highest value of electrical conductivity in Abu Zarag marsh. During the study period the EC was between (1200 and 2172) μs / cm. The reason for the increase in the value of electrical conductivity was due to the arrival of quantities of water from the rivers which helped to drift amounts of salts, and its arrival in the marshes, helped to increase the value of electrical conductivity.

**Figure 6**: Spatiotemporal distribution of EC in Abu Zarag Marsh; a- Temporal variation, b- Spatial variation.

### Total dissolved solids (TDS)

The total dissolved solids, which are associated with high temperatures, increase in the summer and fall in the spring and winter, but due to torrential rains, the TDS were washed out of the marshes. The results of the present study showed that the highest value of the total dissolved solids was in December (940) ppm and the lowest value was in April (413) ppm. It was observed that there is a clear difference in values in all months of the study. This may be due to the difference in monthly additions from contaminated sources. Salinity with Iraqi and international specifications turned out to be identical with those standards. Figure 7a and figure 7b show TDS variation during the period of study.

**Figure 7**: Spatiotemporal distribution of TDS in Abu Zarag Marsh; a- Temporal variation, b- Spatial variation.
5- **Total Alkalinity:** The highest value of the total alkalinity was recorded in March (495) mg / L, and the lowest value recorded in December (168) mg/L. Each type of organism requires a special level of alkalinity where the organism can perform its full activities. Any difference, whether increase or decrease, leads to disruption of vital functions of living organisms and these recorded values are not in conformity with Iraqi standards. Figure 8a and figure 8b show alkalinity variation during the period of study.

6- **Total Hardness (TH):** Figure 9a and figure 9b show that the highest values for the total hardness in Abu Zarag marsh were between (398 - 680) mg / L, and the highest value was in December. The lowest value was in February, due to the large additions of the water from pipeline and sewage in the marshes of neighboring lands.

7- **Turbidity:** Higher values were recorded during April and lower values in February, as expected due to the increase in the number of solid materials, such as mud and silt, which increase during high discharge times and rain. In general, these values are very low due to stagnation. The results of the current study indicate that the monthly changes of turbidity due to an irregular pattern of the marsh as shown in figure 10a and figure 10b according to the speed of flow and discharge.
**Spatial variation**

**8-Dissolved oxygen (DO):** The results of the study show that the values of dissolved oxygen in Abu Zarag marsh, ranged from (5.07-7.9) mg / L, which indicates the high percentage of oxygen saturation, as well as indicates the ability of the phantom to absorb the added quantities of contaminated water. This means the ability of self-purification, which refers to the ability of treating pollution on its own, and without any external treatments.

![Graph of dissolved oxygen](image)

**Figure 11:** Spatiotemporal distribution of DO in Abu Zarag Marsh; a- Temporal variation, b- Spatial variation

**9-Sulfates (SO₄):** The concentrations of sulfur ions ranged between 175-300 mg / L, due to the gypsum nature of the Iraqi soil. It is found that they conformed to the global and Iraqi standards (200-400) ppm, as shown in figure 12a and figure 12b.

![Graph of sulfates](image)

**Figure 12:** Spatiotemporal distribution of SO₄ in Abu Zarag Marsh; a- Temporal variation, b- Spatial variation

**10- Nutrients (NO₃):** Figure 13a and figure 13b show an increase in nutrient concentrations. Nitrate values ranged between (1.3-4.1) μg/ L. The increase in nutrient concentrations in Abu Zarag marsh may be due to increased activity of microorganisms and their availability in large numbers due to the high availability of organic matter from human waste and household detergents. This increase in the activity of these organisms, in turn, leads to an increase in the percentage of decomposition on the Tigris River while the value of NO₃ matched the standard parameter which is (25-50)[15].

![Graph of nitrate](image)

**Figure 13:** Spatiotemporal distribution of NO₃ in Abu Zarag Marsh; a- Temporal variation, b-
Spatial variation

3.2 Comparison Between the Water Quality Parameters During the Study Period with The Same Period During the Previous Years: Comparison of some physical and chemical properties, from 2014 to 2019 for the first quarter of the year for Abu Zarag marsh is shown in figures 14 and 15. It is clear that the worst year was 2018, because of the high values for most of the parameters, while the best year is 2019 because of the heavy rainfall and the flooding from surface runoff come from outside of Iraq, especially from Iran.

![Figure 14](image1.png) **Figure 14**: (PH, Tem., Tur., Do in Abu Zarag marsh)

![Figure 15](image2.png) **Figure 15**: (TH, TDS, COND in Abu Zarag marsh)

4. Simulation of flood in Abu Zarag marsh: Using the arc GIS -arc scene program, the flood was simulated and modeled for the period of the study. The effect of the flood and rainwater, where the percentage of flooding in April was more than 80%, due to the opening of dams of the Tigris River and the opposite currents of the Euphrates River. Figure 16 illustrates the flood in Abu Zarag marsh.

| Date          | Cover area of water (km²) |
|---------------|---------------------------|
| 15/12/2018    | 8                         |
| 15/1/2019     | 15                        |
| 15/2/2019     | 18                        |

![Figure 16](image3.png)
5. Discussion

From this research, it is clear that the period of study from December 2018 to April 2019 was a flooding season; therefore, the concentrations of the parameters under study were diluted due to heavy rainfall as shown in previous figures. When compared to the rate of temperature recorded during the study period, it was found to be identical to the Iraqi standards which are less than 35°C. The pH values recorded in the present study are consistent with many Iraqi studies that referred to the light water bases, the arrival of quantities of water from the rivers' which helps to drift amounts of salts which increases the value of electrical conductivity. Salinity with Iraqi and international specifications turned out to be identical with those standards. The highest value of the total alkalinity was recorded in March (495) mg / L, and these recorded values are not in conformity with Iraqi standards, the total hardness in Abu Zarag marsh were between (398 - 680) mg /L, which slightly exceeded the Iraqi standard, The results of the current study indicate that monthly changes of turbidity due to an irregular pattern of marsh. The results also show that the values of dissolved oxygen in Abu Zarag marsh, ranged from (5.07-7.9) mg / L, which indicates the high percentage of oxygen saturation. The concentrations of sulfur ions ranged between 175-300 mg / L, due to the gypsum nature of the Iraqi soil. The increase in nutrient concentrations in Abu Zarag marsh may be due to increased activity of microorganisms and their availability in large numbers due to the high availability of organic matter from human waste and household detergents. In the second part of the research, when a comparison is made between the period under study and the same period for the previous years, it is obvious that the worst year was 2018, because of the long period of drought for many preceding years, while the year 2019 is the best year because of the rainy season in the first quarter of this year, That is the reason of refilling the Iraqi marshes that suffered from drought for long time, and that is presented in figure 16 in the simulation of flood for Abu Zarag marsh. This refilling helps in restoration of Iraqi marshes and recovering the natural ambient in the south of Iraq.

6. Conclusions

1- Especially in the years of drought, increased concentration of salts, led to pollution of water, as well as stagnant water in some areas. This, in turn, affected the quality of water as most areas in Abu Zarag...
marsh, has no outlet for the drainage of the water of the marshes, and then the renovation, and the impact on water quality in terms of saline concentration.

2-When comparing the values of some environmental variables of the water of Abu Zarag with the standards of Iraq and the world, some of them do not conform to these standards. These must be treated before water is used for drinking purposes.

3-The flooding season helps in refilling the Iraqi marshes, especially Abu Zarag marsh, and that helps in dilution, improvement of water quality parameters, concentrations, and restoration of Iraqi marshes.

7. Recommendations
1-Removing the pollution sources that affect water quality parameters in the marsh.
2-Conduct water modeling, periodically to determine its validity for drinking purposes for humans, animals, or irrigation to prepare a unified geographic information system (GIS) for the marshlands and to use modern techniques such as GIS, and remote sensing to document potential points of entrances and exits and control systems.
3-Qualify the marshes gradually submerging the deep areas first, "using irrigation control systems deployed on the payment of the Tigris, Euphrates and their branches.

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