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Some Ecological Characteristics of Um-Al-Naaj Marsh, Southern Iraq in the Second Most Driest Season during the Last 40 Years

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ABSTRACT

The current study was conducted in one of the most important wetlands in the Middle East and Iraq, the Um-Al-Naaj Marsh, which represents a part of the Huwaiza marsh in Misan Province. This study aimed to evaluate some environmental characteristics in the second driest rainfall season during the last forty years in the Um-Al-Naaj Marsh. Duding the period from 03/11/2020 to 21/07/2021, samples were collected from the studied sites on a seasonal basis, covering four stations in autumn, winter, and spring, and two stations in summer. Some environmental variables were measured (NO3, PO4, Ca, Mg, Cl, K, and Na). Results showed that most of the average values of the environmental characteristics were high in summer, as the values of nitrate and phosphate reached 14.50 and 0.056mgL^{-1}, respectively, and those of calcium and magnesium were the highest in the same season reaching 182.5 and 97.66mgL^{-1}, respectively. The same season witnessed the highest average values for potassium and sodium, with values of 19.8 and 272mgL^{-1}, respectively. On the other hand, values of 1064.5mgL^{-1} and 819.66 mgL^{-1} were recorded for chloride in the spring and summer seasons, respectively. The data presented in this study showed that almost high concentrations of nutrients, cations and anions were recorded in the driest year (2021). Such ecological changes may have potential effect on the composition of marsh ecosystem.

INTRODUCTION

Iraqi marshes (among them Um-Al-Naaj marsh) are designated as Ramsar sites **(Salim *et al*., 2021)** and newly acknowledged by the United Nations as a significant part of the international heritage **(Hamza, 2022)**. Iraqi marshes are important habitats for dense populations and different types of plants and animals, including threatened species, for example, the lesser flamingos (*Phoeniconaias minor*) which is classified as 'near threatened' by the IUCN **(IUCN, 2015)**. Marshes of the southern of Iraq are relatively shallow, and they support fisheries, as well as providing food and income to the Iraqi people **(Richardson *et al.*, 2005; Nama *et al.*, 2024)**. In addition, the mesopotamian marshlands support irrigation of agricultural lands, livestock, and wildlife, and they attract people from Iraq and different countries for tourism **(Merza & Muneam, 2022)**.

Although marsh has a unique ecosystem with crucial benefits, these wetlands were drained and burnt during the 1990s, and as a result, thousands of local people fled. Thus the Arab marshlands at that time witnessed huge ecological changes losing numerous ecological services. Iraq, recently, has been classified as the fifth country, being more vulnerable to the impact of climate change **(Hashim *et al.*, 2022)**. In addition, the dam construction projects on the sources of the rivers of the Tigris and Euphrates **(Janabi, 2010; Metwally *et al.*, 2024)** in addition to the drought events and increased water demands can make more pressure on these sensitive ecosystems.

Most climate change scenarios suggest that Iraq is predicted to get hotter and the drought events are assumed to be more frequent **(Zakaria *et al.*, 2013; Al-Timimi *et al.*, 2024)**. This could mean changes in chemistries and physical conditions, which ultimately will affect the marsh ecosystem in Iraq.

Studies were conducted on the marshes of the southern side of Iraq **(Becker, 2014; Al-Handal & Hu, 2015; Hashim *et al.*, 2019; Al-Taee *et al.*, 2024)**; however, few studies examined the chemical characteristics at the marshes of southern Iraq during severe climate change impact. To our knowledge, most of these studies didn't discuss the implications of the climate change effect associated with the changes in the ecological variables on the components of the marsh ecosystem in the Um-Al-Naaj marsh. The year of 2021 was the second driest year in Iraq during the last forty years which caused a decrease in the water volume of the Tigris River by 29% and the Euphrates by 73% which are the main water providers for the marshes in Iraq (UNICEF report, 2021). The shrink in the marsh size due the low discharge from these rivers and the low rainfall levels could change water chemistry, which will be reflected on the components of aquatic food webs in wetlands such as phytoplankton, zooplankton, fish and birds **(Dodson *et al.*, 2005; Szarek-Gwiazda & Pociecha, 2023)**. As a result, studies on the ecological features of marshes during severe climate perturbations are recommended. This may help understand the future ecosystems of the Iraqi marshes. The main aim of this study was to comprehend some ecological changes during water scarcity in the marshes south Iraq.

MATERIALS AND METHODS

1. Description of the study area

Um-Al-Naaj site is the important part in the Huwaiza marsh and located to the south eastern side of Iraq (Fig. 1). The Huwaiza marsh is primarily fed by two rivers: The Musharah and Al-Kahla rivers originated from the Tigris River **(Al-Zubaidi *et al.*, 2017)**. The surface area of Um-Al-Naaj site ranges from 140 to 200km^2 **(Salman *et al.*, 2014)**.

The average depth of Iraqi marsh including the study site is between 2 to 7m depending on the discharge released from the Tigris and Euphrates rivers and the rainfall levels **(Al-Karatt, 1975)**. The mean annual evaporation can reach 3000mm in Iraq **(Rzóska, 2012)**. Air temperature reaches up to 50°C and decreases to a minimum of 4°C in winter **(Hassan & Hashim, 2020; Hassan & Nile, 2021)**. The soil of the surrounded catchment of marshland is mainly composed from silt and fine clay; these eroded and transported from distributaries of the the Tigris rivers, the Musharah and Al-Kahla **(Al-Zubaidi *et al*., 2017)**. The catchment or land vegetation of this marsh includes dense shrubs and grasses. The shoreline and the area inside the marsh are dominated by reed and relatively dense typha beds **(Al-Abbawy & Al-Mayah, 2010)**.

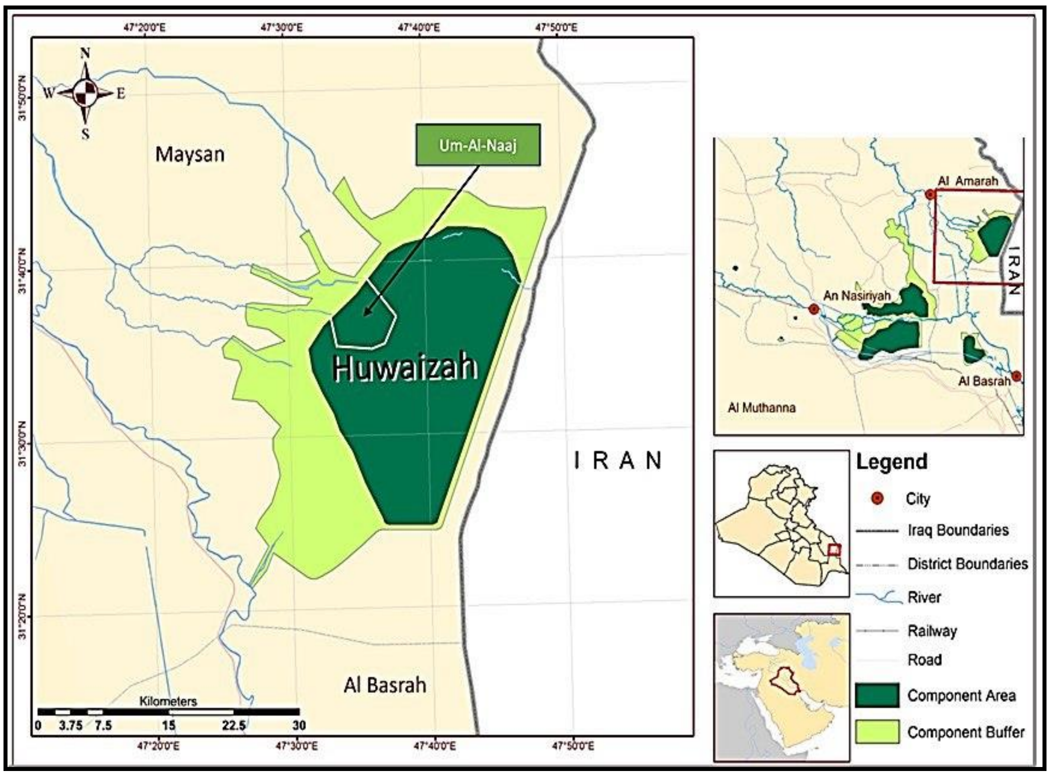

Fig. 1. Map showing the Middle East, Iraq, Huwaiza marsh, and Um-Al-Naaj study area, modified from (https://whc.unesco.org/en/list/1481/maps/).

The phytoplankton is dominated by diatoms, chlorophytes, and cyanophytes **(Hammadi *et al*., 2007)**. The dominant species of plants are *phragmites australis*, the *Potamogeton* sp., *Ceratopyllum demersum*, and the *Najas* sp. **(Salman *et al*., 2014)**. The invertebrate community is composed of different groups, including the Cladocera, Copepoda, Rotifera, Ostracoda, Nematoda, Annelida, insects, snail, shrimp, isopod, amphipod, cirriped, mussels, and the spiders **(Al-Sodani *et al*., 2007; Ali *et al*., 2007)**. Fish community is rich in different species, viz. *Liza abu*, *Barbus luteus*, *Carassius auratus*, and *Alburnus mossulensis* **(Mohamed *et al*., 2008)**. The iconic animal in the

Iraqi marshes and in Um-Al-Naaj marsh is the buffalo (*Bubalus bubalis*) **(Al-Zubaidi *et al.*, 2017)**.

2. Samples collected

Using a boat, samples were seasonally collected from the study site between 03/11/2020 and 21/07/2021 from four locations in autumn, winter and spring and two locations in summer due to the severe reduction in the surface area during the drought at this time. All samples were gathered during day time between 9 a.m. and 3 p.m., 10 cm depth from pelagic zone. These locations were chosen to be representative to the length of the marsh. Seasonal sampling was conducted to figure out the changes in the condition of the Um-Al-Naaj marsh.

Different ecological variables (NO3, PO4, Ca, Mg, Cl, K and Na) were measured according to **APHA (1998)**, and all samples were analyzed on the same day of the sampling. Three to four replicates were conducted for each ecological variable considering each station.

RESULTS

The results of the environmental characteristics are shown in Fig. (2). It was noticed that the highest average value of nitrate with a standard deviation (±SD) was 14.50±3.76 mgL^{-1} during summer, while the lowest average value was 4.23± 0.81 mgL^{-1} in autumn.

In addition, the highest mean values and standard deviations (±SD) for phosphate were 0.056±0.020 mgL^{-1} in summer, while the lowest mean value was 0.025±0.011 mgL^{-1} in winter.

On the other hand, the highest average concentrations of Ca and Mg with standard deviations (±SD) were 182.5±7.63 mgL^{-1} and 97.66±2.51 mgL^{-1}, respectively, in summer, while the lowest values were 155.75±16.60 mgL^{-1} in autumn and 76.5±17.31 mgL^{-1} in spring, respectively. K and Na concentrations were high in this year (2021), particularly in summer. Notably, the highest average values with a ±SD for potassium and sodium were 19.8±1.49 mgL^{-1} and 272±10.58 mgL^{-1}, respectively, in summer, while the lowest values were 4.28±1.63 mgL^{-1} and 126.25±13.76 mgL-1, respectively, in autumn. The highest average value and the ±SD for chloride (Cl) was 1064.5±136.70 mgL^{-1} in spring, whereas the lowest average value was 410±84.85 mgL^{-1} in autumn.

Table 1. Environmental characteristics measured in Um-Al-Naaj marsh between 03/11/2020 and 21/07/2021

Seasons / Variable	Autumn	Winter	Spring	Summer
NO_3 (mean± S.D)	4.23±0.81 mgL^{-1}	7.23±1.77 mgL^{-1}	6.65±1.25 mgL^{-1}	14.50±3.76 mgL^{-1}
PO_4 (mean± S.D)	0.026±0.013 mgL^{-1}	0.025±0.011 mgL^{-1}	0.046±0.024 mgL^{-1}	0.056±0.020 mgL^{-1}
Ca (mean± S.D)	155.75±16.60 mgL^{-1}	162±12.58 mgL^{-1}	160.75± 17.28 mgL^{-1}	182.5±7.63 mgL^{-1}
Mg (mean± S.D)	84. 75±11.23 mgL^{-1}	92.5±7.63 mgL^{-1}	76.5±17.31 mgL^{-1}	97.66±2.51 mgL^{-1}
K (mean± S.D)	4.28±1.63 mgL^{-1}	9±3.31 mgL^{-1}	14.90±1.73 mgL^{-1}	19.8±1.49 mgL^{-1}
Na (mean± S.D)	126.25±13.76 mgL^{-1}	161.66±32.14 mgL^{-1}	222±25.61 mgL^{-1}	272±10.58 mgL^{-1}
Cl (mean± S.D)	410±84.85 mgL^{-1}	793.33±15.27 mgL^{-1}	1064.5±136.70 mgL^{-1}	819.66±30.50 mgL^{-1}

DISCUSSION

The concentrations of nitrate in this study were higher than those previously reported for the Iraqi marsh, which were between 0.04 and 8.04 mgL^{-1} **(Al-Saad *et al*., 2010; Al-Badran *et al*., 2021; Alshaaban & Al-Hejuje, 2021)**. It is unlikely that the high nitrate value in the present work was attributed to agriculture activates and wastewater due to the decreasing inflow of the rivers into the study site at this time. The highest value of nitrate in summer is probably related to the poor growth of aquatic plants and phytoplankton due to the decrease in the water volume, and consequently the surface area of the water in this marsh at this time.

In addition, this nutrient was likely not important for the terrestrial plants during this severe drought in 2021. It was found that nitrate uptake decreased during low water availability **(Gloser *et al*., 2020)**. As a result, accumulated nitrate resulted from agriculture activities in the catchment of Um-Al-Naaj marsh, and other surrounded agriculture sites could be driven into marsh during dust storms, which are very common in Iraq, especially during drought seasons **(Al-Khudhairy *et al*., 2023; Awadh, 2023)**. Dust storms were found to be the main driver for high concentrations of nitrate in the water in North China **(Wang *et al*., 2023)**.

The results of phosphate were higher than those reported in several studies on Iraqi marshes **(Al-Lammi, 1986; Al-Imarah *et al*., 2006; Al-Saad *et al*., 2010; Al-Kenzawi *et al*., 2011; Talal, 2013)**. The high levels of phosphates in the present study, particularly in spring and summer, may be due to the decrease of water volume via the low discharge of the Tigris River, which causes an accumulation of nutrients at this time. This finding is in consistence with those of previous studies **(Kassim, 1986; Al-Kenzawi, 2007)**. In addition, the nutrient release from the decomposing animals, plants and microorganisms remains in such dry year may have additional contributions to high phosphate levels in the second driest year during the last forty years in Iraq. The results of this study coincide with those of **Jeppesen *et al*. (2009)**, who recorded high phosphate concentrations during the dried periods in the shallow Lake Mogan in Turkey.

It seems that cations and anions (Ca, Mg, K, Na, and Cl) followed a similar pattern regarding their high values in the water of Um-Al-Naaj marsh in this study. The current finding suggests that the increased levels were mostly reaching the peak during the drought event, particularly in summer months, and the values of the present study were in most cases higher than those recorded in previous studies on the Iraqi marsh **(Maulood *et al*., 1979; Hussain & Grabe, 2009; Al-Saad *et al*., 2010)** and the Tigris and Euphrates rivers **(Al-Mayyahi *et al*., 2018; Al-Saedi, 2023)**, which provide the main water inputs for the marshes in Iraq. This is likely due to the average of precipitation during the sample collection of the present study, and its value was lower than those reported in the aforementioned studies. For example, in the current study, the average of precipitation in the dry year of 2021 was about 148mm in comparison with the time of sample collection of the study of **Al-Saad *et al*. (2010)**, which was mainly in 2006, recording a high average precipitation value of about 222.23mm **(CCKP, 2021)**.

The concentration levels of the parameters in this study were almost unacceptable and did not meet the WHO guidelines in 2022 for water safety and quality. The acceptable limits of Ca, Mg, K, Na, Cl, NO3 and PO4 are 100 mgL^{-1}, 50 mgL^{-1}, 20 mgL^{-1}, 200 mgL^{-1}, 250 mgL^{-1}, 50 mgL^{-1} and 0.1 mgL^{-1}, respectively **(WHO, 2022)**.

It is known that the stability of Iraq marshes is mainly driven by the seasonal stability of rainfall which sustain the sufficient water inputs for marshes and their main river inputs (e.g. the Tigris and Euphrates rivers), therefore, an unpredicted decrease or fluctuations in the precipitation levels can affect the ecological characteristics, as shown in this study. Although the data of the ecological characteristics in the present study were limited to one snapshot, such fluctuations in the ecological state of the Iraqi marshes (for example Um-Al-Naaj marsh in the present study) can have a negative impact on their biota.

The levels of the nitrate and phosphate in the present study reflected a high eutrophic state which can encourage the cyanobacteria to be more dominant and permanent in the environment of the Iraqi marshes. The cyanobacteria have serious consequences on the human health due to toxins that can be produced by the different species of cyanobacteria

(Bell & Codd, 1994; Dittmann & Wiegand, 2006; Ubero-Pascal & Aboal, 2024). Moreover, the cyanobacteria are unfavourable food items for numerous invertebrates, such as zooplankton groups and insects since these algae produce toxins, and they can affect the digestive enzymes of several zooplankton, consequently, reducing the feeding rate of zooplankton **(DeMott & Moxter, 1991; Rohrlack *et al*., 2004)**.

In addition, the cyanobacteria were found to be the main reasons for fish deaths and causing problematic diseases for other organisms such as mammals, including birds and buffalos **(Krienitz *et al*., 2005; Badar *et al*., 2017; Jos *et al*., 2017; Igwaran *et al*., 2024)**.

The severe decline in the precipitation levels in Iraq in 2021 was likely the main driver for changing water chemistry. Such change might affect the structure, abundance, and diversity of the phytoplankton, zooplankton communities which are important components in the aquatic food webs, and they play important roles in the stability, function, and the efficiency of the aquatic food webs **(Hébert *et al*., 2017; Vallina *et al*., 2017)**. For example, the maximum average value of Cl in the present study was 1064.5 mg L^{-1}, which is about 3.5 times higher than the previous average values of Cl (304.70 mg L^{-1}) recorded by **Al-saad *et al*. (2010)** for the same marsh. It was found that the zooplankton abundance and diversity (e.g Cladocera, Copepada) were declined by the elevation of Cl at 162mg L^{-1} **(Hintz *et al*., 2017)**.

The climate of Iraq is predicted to experience prolonged periods of drought, and this will be very common in the near future due to the climate change associated with the low rainfall levels, particularly in the south of Iraq **(Zakaria *et al*., 2013; Al-Mukhtar & Qasim, 2019; Hassan & Hashim, 2021; Hassan & Nile, 2021)**. This probably indicates high fluctuations in the physical, chemical, and biological characteristics and a reduction in the depth and size of the marshes. Future work with frequent sampling over several years with more tools, such as stable isotopes technique and remote sensing approach, are needed to understand the marsh ecosystem response in Iraq to the climate change, which will ultimately help in better management for these marshes.

CONCLUSION

The data presented in this study showed that high concentrations of nutrients, cations and anions were detected during the driest year of 2021. Such ecological changes may have a potential effect on the composition of the marsh ecosystem, aligned with an ultimate impact on the function and services of these marshes.

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