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Evaluation of Physiochemical Factors in Saffia Nature Reserve, Southern Iraqi Marshes, using Geographic Information System Techniques

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Abstract: This survey was conducted during four seasons in nine stations representing the Saffia Nature Reserve (SNR) in Al-Hawizeh marsh, southern Iraq, which has 44 km^2. Physical and chemical parameters were monitored; including natural water quality parameters such as water temperature, pH, electric conductivity and dissolved oxygen in addition to levels of nutrients from September 2019 to August 2020. The current study discussed the possible use of spatial analysis techniques to characterize the temporal and spatial distribution of water prediction properties employing geographic information systems (GIS) to determine water quality parameters at SNR. In general, all parameters are within the acceptable limit of freshwater for aquatic life except electric conductivity. The current survey could serve as a basis for more monitoring and restoration of the marshland environment. The use of a geographic information system in evaluating the water quality depends on the laboratory values of water samples and spatial analysis of these properties employing inverse interpolation of the weighted distance. It was possible to map water quality indicators along the study area for nine sites and six water quality indicators. The production of water quality maps will improve monitoring and enforcement of standards and regulations for better management and control. This study suggested continuous monitoring of the physical and chemical characteristics of water marshes and water bodies, and the study of factors affecting the increase in the concentration of elements and nutrients and comparing them with environmental determinants.

Keywords: Physiochemical factors, Saffia Nature Reserve, Geographic Information System Techniques

Environmental studies occupy a vital space between basic, applied, and human sciences due to the occurrence of various processes between humans and ecological activities. Increasing pressure on natural resources raised great interest in evaluating, protecting, and maintaining ecosystems to become the foundations for future development processes (Al-Asadi and Maatouk 2013). With growing population growth and economic development, wetlands around the world are now decreasing and degrading (Davidson 2014, Dixon et al 2016). It is also reasonable to acknowledge wetlands as an indispensable resource for humans. In the Middle East and Western Europe, the Mesopotamian Marshlands are among the largest water bodies (Hussain et al 2012) as they occupied a wide area in southern Iraq, where the marshes of southern Iraq are considered to be the gardens of Aden on earth cos of their distinguishing characteristics and their beauty in a beautiful and picturesque environment. The marshes are considered a place for the emergence of the earth (Khalaf and Almukhtar 2005). The marshes of Mesopotamia are also classified as one of the largest bird and fish-rich natural reserves in the world, as there are reeds, sedge plants in the marshes but those plants in the marshes are considered to be among the most important areas for birds, their livelihoods, shelter and migration from different parts of the world (Kowais 2005). The Mesopotamian marshes consist of three large marsh complexes in Southwest Asia, including three main areas in the north, the Hawizeh Marsh, in the middle, the Central Marsh (Chibayish), and the Hammar Marshlands in the south, all of which are rich in natural resources and biodiversity. A unique wetland in the world during the forty sessions of the World Heritage Committee according to the third and fifth cultural criteria and the ninth and tenth natural standards in Istanbul in 2016. The conservation of invasive species, the most significant of which is the Convention on Biological Diversity, signed at the 1992 Earth Summit. The nature reserves are considered a natural center for researchers, university, and graduate students and exploit existing living organisms to conduct various scientific and medical studies and space for scientific experiments.

Water is the basic requirement of all species on the earth. Surface water tends to be an important water source because of the rise in its consumption for drinking, irrigation, water supply, and industrial uses, etc., a necessary resource is required. Rises in the agricultural and industrial sectors need more freshwater (Chen et al 2019). In order to assess the quality of water, it is necessary to specify the information on the state of water quality and to recognize factors that impact the effectiveness of water as well as the critical locations within the catchment. This can be accomplished by collecting water samples and then measuring the physical and chemical parameters at different sites in the research area (Ogbozige et al 2018).

GIS is necessary for the analysis of water bodies, to restore and manage water resources, including spatial and temporal data for all water sources, and to provide an effective database for a computer to store, manipulate and analyze data. For the past 30 years, GIS was used globally to obtain the requisite information to control different water bodies worldwide. Together with computer simulations, remote sensing and GIS software are effective tools to provide a solution for future management of the water sources, especially water quality control plans.

MATERIAL AND METHODS

Study Area: Al-Hawizeh Marsh is currently located within the southeastern part of the alluvial plain, precisely before the Tigris River meets the Euphrates River at Al-Qurna, and administratively it follows the northern part of the marsh to Maysan Governorate. In contrast, the southern part follows the Basrah Governorate. The total area of the marsh in the flood season is more than 3500 km^2, and this area decreases to 650 km^2 during the Drought season, and the site of the marsh on the Iraqi side is up to 2350 km^2. About 1900 km^2 were re-flooded after 2003. The capacity of the marsh is 5896 million cubic meters, with a surface area of 1800 km^2 for a level of 7 meters above sea level. SNR is one of the largest reserves in Iraq (E: 47° 40.413 ', N: 31° 10.887'), located within Al-Saffia marsh, east of Al-Dasim marsh, is rectangular with an area of 44 km^2, length 11 $km^{2,}$ and width 4 km^2. A dam parallel to the border strip with the Iranian side and the west is a dam parallel to the border barrier, and it is connected with the Ajirda dam. SNR is one of the types of wetlands. It was established in 2006 by the Directorate of Agriculture in Basra Governorate to preserve biodiversity. Others, such as insects, crustaceans, and fish, especially during periods of migration, mating, and spawning as shown in Figure1. Locations of the sampling stations selected in the present study showed the most important sources of the Rivers, the source is the work of the researcher based on the administrative map of Iraq 1/1000000, the map of Basra Governorate 1/250000, and the USGS satellite map for the year 2021, using ArcMap Ver. 10.8.

Water sample collection and analysis: Water samples were collected from September 2019 to August 2020 from nine different stations in SNR, Al-Hawizeh Marsh (Fig. 1). The environmental variables, were recorded in the field, a standard thermometer for temperature within 10-100˚C, the potential of hydrogen ion (pH) and Electrical Conductivity (EC) (µs cm^{-1}) was measured by A Multiprobe type HANNA multimeter after calibrating the device before going to fieldwork with Buffer solutions, 4, 7 and 9, Milwaukee device to make the measurements of dissolved oxygen (mg L^{-1}). Water samples were taken from the field for the determination of NO_3 and PO_4 in the laboratory. Active nitrite NO_3 was measured according to American Public Health Association and active phosphate PO_4 by method of Strickland and Parsons (1976).

Data map: The base map of the study area is obtained by using ArcGIS 10.8 software. We pick WGS 1984 (Geographic Coordinate System) as a spatial reference map in the ArcGIS 10.8 program. Lastly, IDW was performed as an interpolation in spatial analyst. Interpolation is used to predict the value of attributes at un-sampled sites using values at locations within the same region

Statistical analysis: Data were statistically analyzed using Minitab ver.19, below the probability level of (0.05).

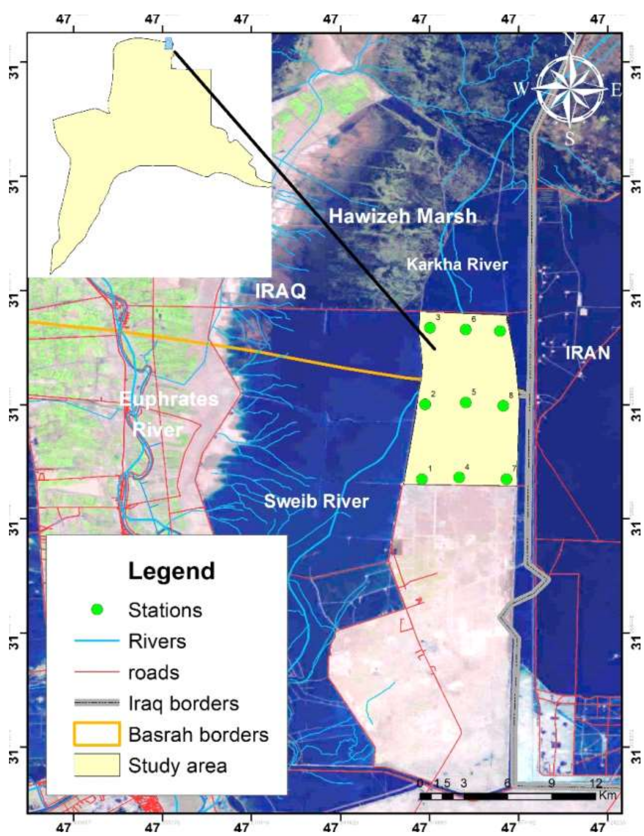

Fig. 1. Locations of the sampling stations selected in the present study and showing the most important sources of the Rivers

RESULTS AND DISCUSSIONS

Physical and Chemical Parameters

Water temperatures: The highest water temperature was 30.9°C in Station No.9 during the summer season, while the temperature decreased to its lowest levels in the winter season when it was 13.4°C in Station No. 3. Statistical analysis showed significant differences between seasons and no significant differences were observed between stations. This variation is due to the nature of the Iraqi climate in general, as thermal extremes characterize it, so it is hot and dry in the summer and cold and rainy in the winter may be to the intensity of solar radiation throughout the hours of the day, especially in the summer, slight differences or differences were recorded between the water temperatures on the surface and the lower layers inside the water column due to the shallow water in the marshes. This variation in water temperature helps in the abundance and growth of different species of organisms in the area (Douabul et al 2013). The local changes in water temperature may be due to the difference in the time of sampling, where the temperature is low in the early morning and then starts to rise as approach the middle of the day. In general, the waters of the marshes in southern Iraq is characterized by the difference in temperatures during the seasons of the year and this corresponds to the study of Al-Thahaibawi (2014) where the water temperature in the southern marshes ranged between 14.3 -35.6°C in winter and summer, respectively (Fig. 4 a-d). Mohammed (2010) in Al-Hammar marsh in southern Iraq observed that the temperature ranged from 15°C in February to 31°C) in August.

Hydrogen ions (pH): The pH value is one of the important measurements that determine water bodies' suitability for different purposes. It also plays a vital role in rivers (Al-Hassani et al 2006, Yousry et al 2009). The pH recorded in the present study was within a narrow range. They tended to be alkaline as it is common in Iraqi inland water due to Iraqi natural waters' with relatively high content of calcium bicarbonate (Fig. 4). The lowest pH values in the study area reached 7.8 in No.2 and No.6 during the summer season, while the highest was 8.7 in station No. 5 during the winter. There were significant differences between the seasons at the probability level as well as the presence of significant differences between the stations (Fig. 6 a-d). In the present study, alkalinity is the predominant characteristic of the water in the stations. These results are in agreement with the pH of freshwater in different regions of the world (Baudo and Beltrami 2001) as well as, with previous local studies on internal Iraqi waters (Hinton and Maulood 1980), The alkaline

Fig. 2. Saffia nature reserve

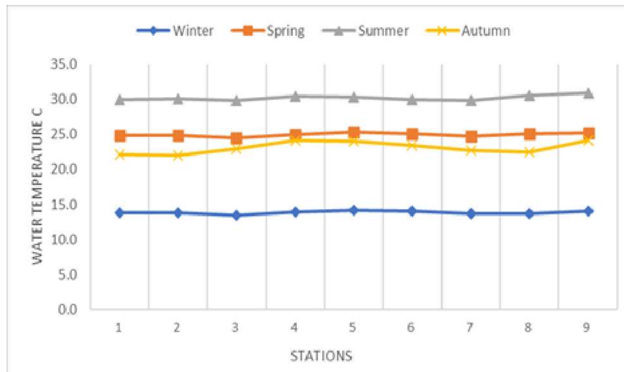

Fig. 3. Water temperature (°C) in SNR

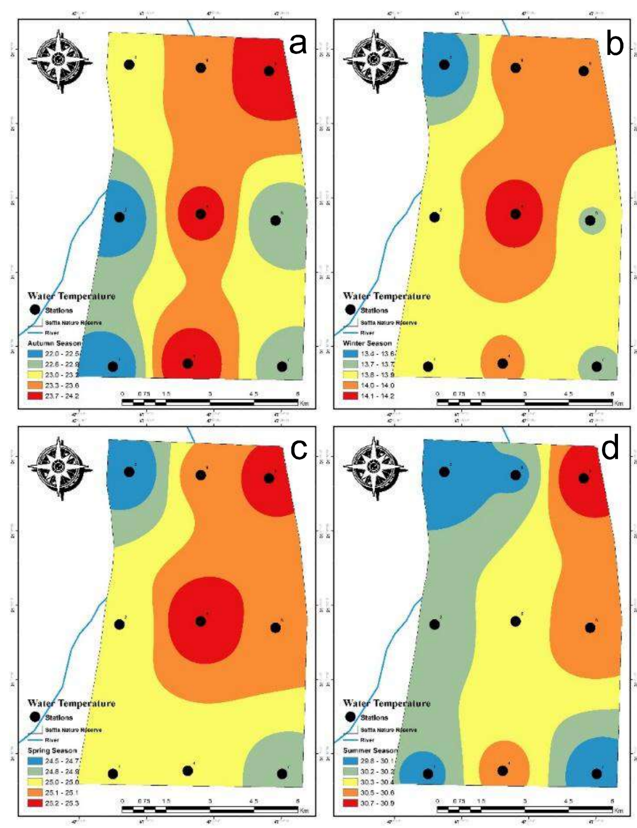

Fig. 4. Spatial distributions of WT using IDW interpolation: (a) autumn 2019, (b) winter 2020, (c) spring 2020, and (d) summer 2020

characteristic of Iraqi waters is mainly due to the nature of lime sediments of the marsh, so the lower pH values may be due to the nature of acid or the increase in the concentration of dissolved carbon dioxide as a result of the organic decomposition of the materials. Bora and Goswami (2015) indicated that the pH value of rivers depends on several factors, including local geology, the environment, as well as human influences. The runoff of alkaline substances due to heavy rains is one of the factors affecting the high pH value of water (Rubio-Arias et al 2013), Higher temperatures lead to an increase in evaporation rates, which leads to an increase in the concentration of dissolved salts in water, which raised the pH value in the base direction (Odjadjare and Okoh 2010).In general, the waters of the Iraqi marshes are characterized by a low pH value in summer and high in winter, and this agrees with (Mohammed 2010, Al-Kenzawi et al 2011, Al-Saboonchi et al 2011, Al-Rikabi and Al-Kubaisi 2014, Al-Abbawy and Al-Zaidi 2018). The current study of the pH values at Station No.5 during the winter season recorded a value higher than the permissible limits according to the World Health Organization (6.5 - 8.5).

Electrical conductivity (EC): Electrical conductivity (EC) is a measure of the ability of an aqueous solution to carry an electric current, depending on the ions, their equivalence, total concentration, and their movement, as well as on the temperature at the time of measurement. The highest value of electrical conductivity was 7.1 µS cm^{-1} in station No.2 in the spring. The lowest value was 3.44 µS cm^{-1} in station No.5 in the autumn season (Fig. 7). The statistical analysis showed that there was significant differences between the seasons and was noticed that there were no significant differences between the stations (Fig. 8 a-d). The seasonal and monthly differences in the electrical conductivity values is attributed to the fact that it is associated with a decrease in water levels and an increase in the rate of evaporation in the summer, which leads to the dissolved ions being more concentrated and this leads to an increase in the electrical conductivity values in the water (Al-Kenzawi et al 2011), The reason for the low values of electrical conductivity in the marshes water may be due to the dilution of salts by precipitation (Al-Saad et al 2010). The electrical conductivity value is also clearly related to the total soluble solids, as it reflects the water content of salts, nutrients, and organic materials (Parmar and Parmar 2010). It is well known that the Iraqi marshes were exposed to years of drought, which led to an increase in the concentration of salts in the sediments (Al-Abbawy and Al-Mayah 2010, Al-Abbawy et al 2011).

Dissolved oxygen (DO): Dissolved oxygen in water is the first evidence to prove the purity of natural water since most aquatic organisms depend on the presence of dissolved

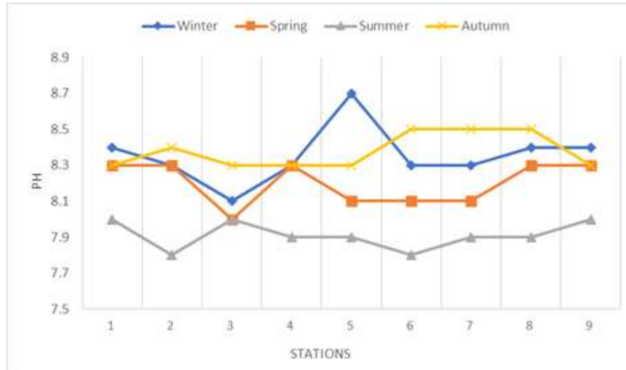

Fig. 5. Hydrogen ion concentration (pH) in SNR

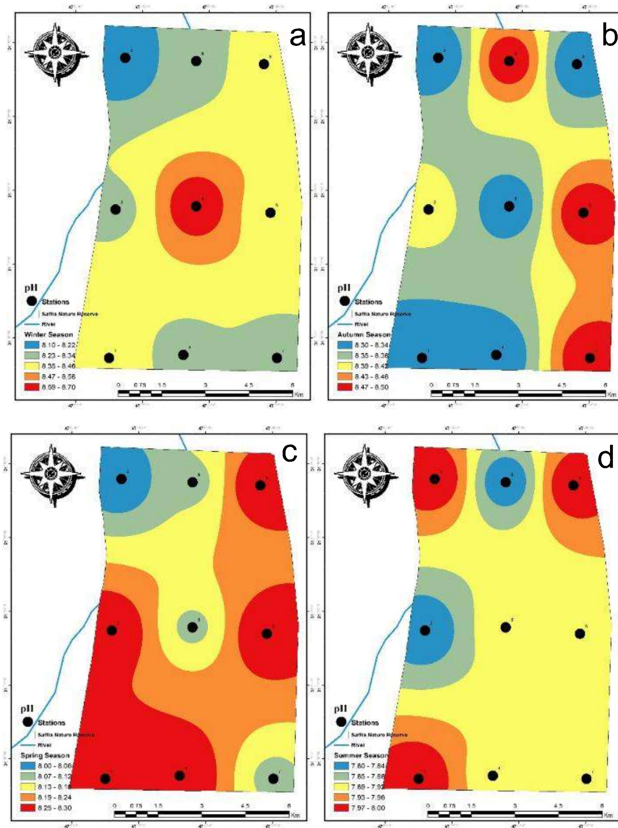

Fig. 6. Spatial distributions of pH values using IDW interpolation: (a) autumn 2019, (b) winter 2020, (c) spring 2020, and (d) summer 2020

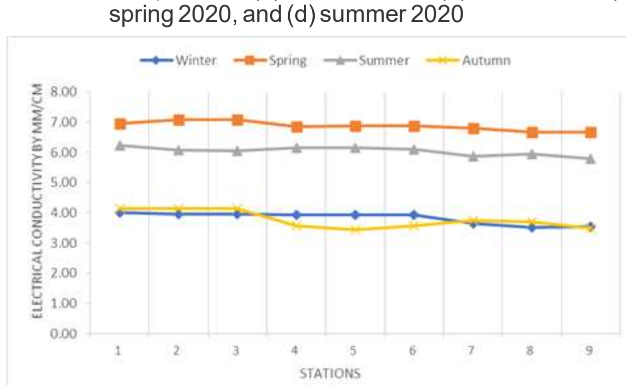

Fig. 7. Electrical Conductivity (EC) µm cm^{-1} in SNR

oxygen to survive (Singanan et al 2008). For that reason, dissolved oxygen is one of the most critical factors that affect the quality and degree of water bodies of water-pollution in it (Yang et al 2007). The results of dissolved oxygen in the current study showed that the highest dissolved oxygen was (10.1 mg l^{-1}) in station No. 8 during the winter season (Fig. 9). The lowest value was in the summer season (5.5 mg l^{-1}) in stations No. 4 and 5. The statistical analysis showed the presence of significant differences between the seasons and no significant differences were observed between the stations. There is a significant correlation relationship. Negative between dissolved oxygen and temperature (Fig. 10 a-d). In general, the low value of dissolved oxygen concentrations recorded during the summer season and the highest values represented in the winter season (Mohammed 2010, Al-Kenzawi et al 2011, Al-Saboonchi et al 2011, Al-Zuwar et al 2012, Douabul et al 2013, Al-Rikabi and Al-Kubaisi 2014, Al-Asadi 2014, Al-Abbawy and Al-Zaidi 2018). The presence of dissolved oxygen in the aquatic environment is affected by many factors, including the amount of rain, water temperature, salinity, the decomposition of organic matter in the water, the presence of aquatic plants, and the presence of pollutants from 4 mg l^{-1} (Cameron et al 2013). Most of the study results were for dissolved oxygen concentrations in the waters of SNR above the permissible limits according to the World Health Organization (6 mg l^{-1}).

Nutrients

Active nitrate (NO_3^-): The nitrate anion is one of the inorganic nitrogen forms in water and nitrate, and ammonia. It is also a significant nutrient that contributes to building the vital activities of most living organisms. The high nitrate value

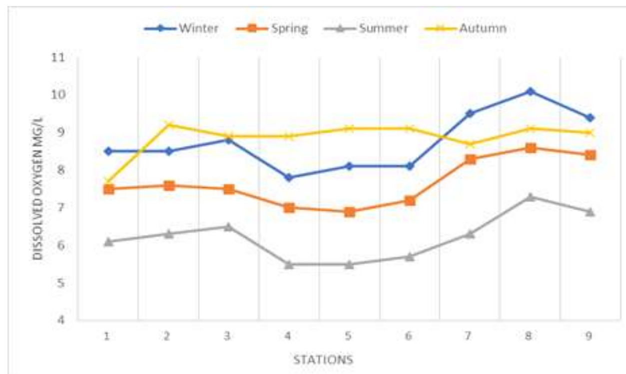

Fig. 9. Dissolved Oxygen (EC) mg L^{-1} in SNR

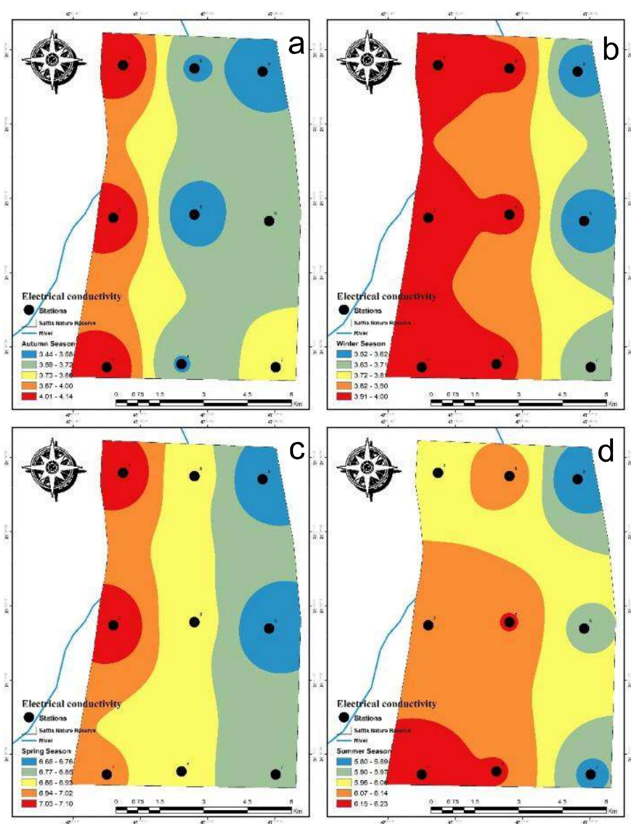

Fig. 8. Spatial distributions of E.C. values using IDW interpolation: (a) autumn 2019, (b) winter 2020, (c) spring 2020, and (d) summer 2020

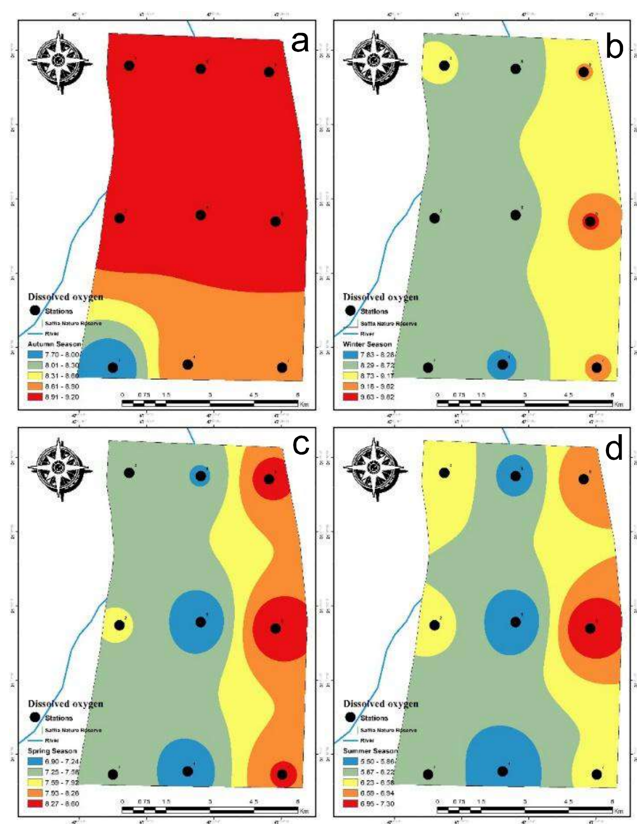

Fig. 10. Spatial distributions of DO mg L^{-1} values using IDW interpolation: (a) autumn 2019, (b) winter 2020, (c) spring 2020, and (d) summer 2020

is due to the flow of nitrogen-rich floodwaters that bring in large quantities of contaminated wastewater (Pradeep et al 2012). The nitrate concentration reached the highest value (8.04 mg L^{-1}) in station No.1 in the winter season and the lowest was in station No.6 (0.53 mg L^{-1}) during the same season (Fig. 11). During the seasons, the sufficient nitrate concentrations were in the winter and spring seasons and the lowest were in the summer and autumn seasons. There was significant difference between the seasons. In contrast, no significant differences were between the stations and there is a significant negative correlation between nitrate concentrations and water temperatures. The reason for the high nitrate concentrations during the winter season may be to the rains, which in turn dissolve the organic compounds and nitrogen fertilizers on the banks of the rivers (Lomoljo et al 2009), as well as the low nitrate consumption by phytoplankton and aquatic plants (Twomey and John 2001, Al-Saadi et al 2008). The increase in oxidation of nitrite to nitrate as a result of the decrease in water temperature, which increases the concentrations of dissolved oxygen (Hussein and Fahad 2008). In the summer season, nitrate concentrations decreased most of the study stations. It may be caused by an increase in temperature and decrease in dissolved oxygen concentrations, which leads to the reduction of nitrates to nitrites (Al-Emara et al 2001). This study is in agreement with previous studies on the marshes in southern Iraq in terms of high active nitrate concentrations in winter and spring seasons and low in summer and autumn seasons (Al-Saboonchi et al 2011, Douabul et al 2013, Al-Thahaibawi et al 2014, Al-Rikabi and Al-Kubaisi 2014). The results of the active nitrate concentrations in the current study did not exceed the World Health Organization, which is 50 mg l^{-1} (Fig. 12 a-d).

Active phosphate (PO_4^{3-}): Phosphorus is essential for different living organisms, and its increase also leads to an overgrowth of microorganisms in large quantities, which affects other aquatic organisms (Al-Emara et al 2001, Bakan et al 2010). The current study results showed that the highest reactive phosphate concentration was at station No.9 in the spring season (0.133 µg L^{-1}). The lowest was at station No. 6 in the winter season was (0.005 µg l^{-1}). The study stations' show that the highest value of the reactive phosphate concentration was in the summer and spring seasons during seasons. The lowest concentrations were in the winter and autumn seasons (Fig.13). The statistical analysis showed a significant difference between the seasons as well as the presence of significant differences between the stations at the probability level. There is a significant negative correlation at the between the active phosphate concentrations and water temperatures (Fig. 14 a-d).

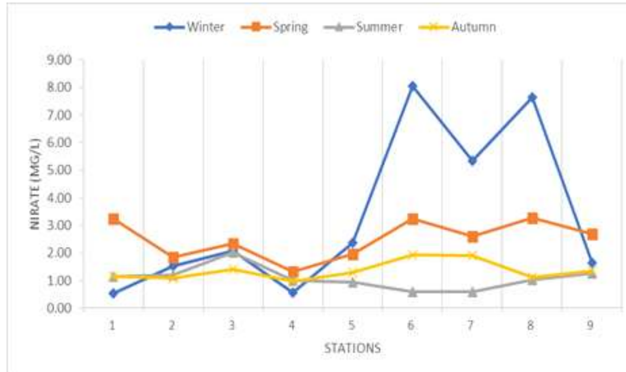

Fig. 11. Nitrate concentration (NO_3^-) mg L^{-1} in SNR

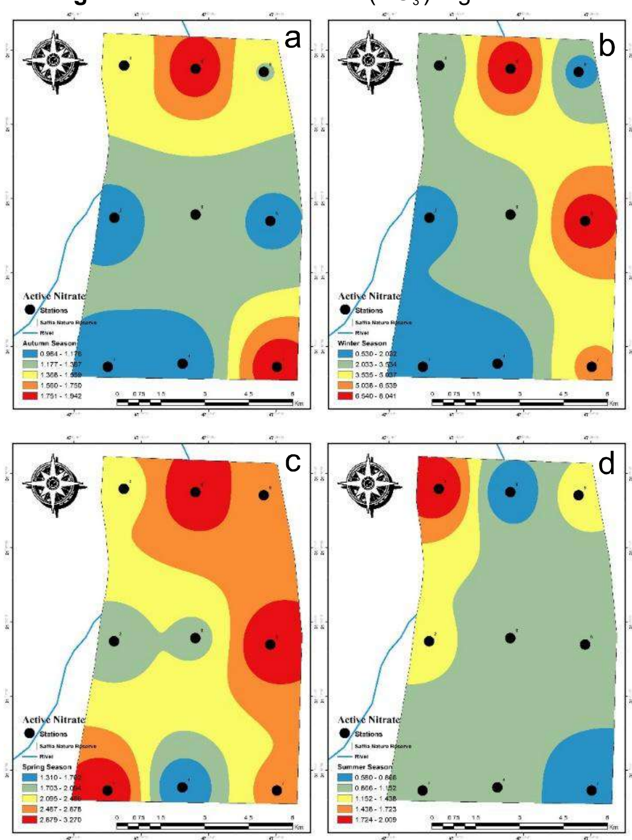

Fig. 12. Spatial distributions of NO_3^- mg L^{-1} concentrations using IDW interpolation: (a) autumn 2019, (b) winter 2020, (c) spring 2020, and (d) summer 2020

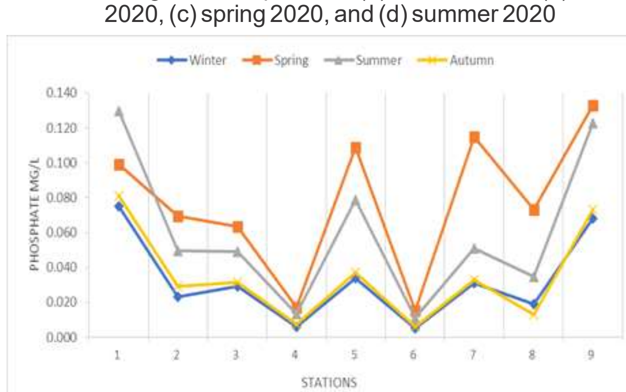

Fig. 13. Phosphate concentration (PO_4^{3-}) µg l^{-1} in SNR

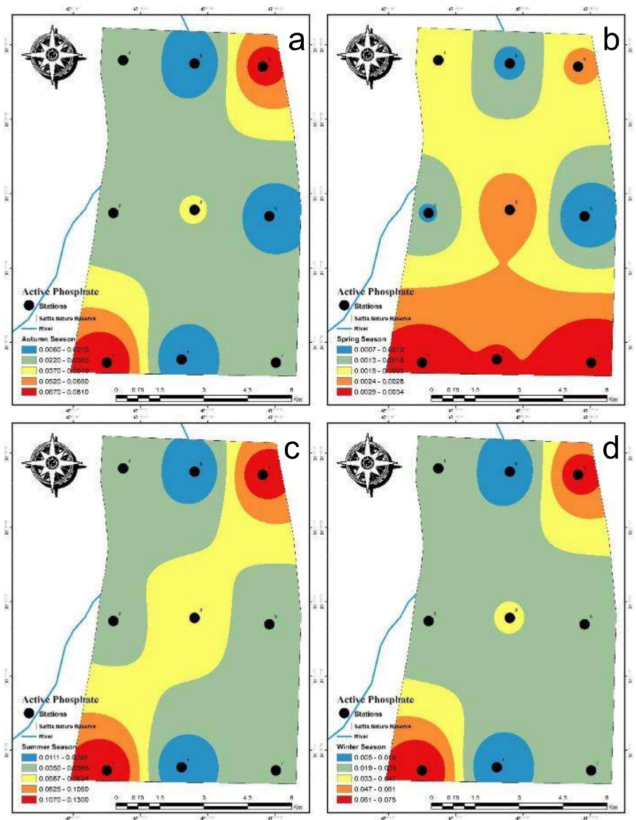

Fig. 14. Spatial distributions of PO_4^{3-} concentrations using IDW interpolation: (a) autumn 2019, (b) winter 2020, (c) spring 2020, and (d) summer 2020

CONCLUSIONS

The results of the study showed deterioration in water quality due to the high electrical conductivity and best properties were in the summer season. There is a negative exponential relationship between water temperatures and pH and dissolved oxygen, and a positive relationship between water temperature and electrical conductivity.

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