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Qualitative Characteristics Of The Diwaniyah River Water And Its Suitability For Irrigating Agricultural Crops In The Diwaniyah District

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ABSTRACT

The current study will be used to identify the water pollution rates in the Al-Diwaniyah River (Shatt Al-Diwaniyah) located in Al-Diwaniyah District and to assess the effects of water pollution on agricultural crops. The research was based on the thorough collection of information, statistics, received in respect to the official bodies of interest and the field research that assumed the gathering of the information and water samples at the different points of the river. The samples have been georeferenced with the help of GPS machine and have been studied at the chemical laboratory. Furthermore, Geographic Information Systems (GIS) were used to draw a group of thematic maps, which were vital to the study.

The findings indicated that there is an issue of a high level of temperature in the water of the Al-Diwaniyah River with the highest of 34.2 C recorded in July and the lowest of 10.3 C recorded in January. This thermal rise had serious impacts on concentrations of other parameters especially the electrical conductivity (EC), which was up to 3,465 -1 cm. As compared to the limits set by the Islamic Educational, Scientific and Cultural Organization (ISESCO), it was discovered that pH, potassium (K), sodium (Na) and sulfates (SO 4) concentrations in the considered locations make the water not suitable to be used in the irrigation process. Nonetheless, the total dissolved solids (TDS) in the examined sites were identified to be within the acceptable range based on the category of the U.S. Salinity Laboratory (USSL).

Keywords: - Water Pollution, Al-Diwaniyah River, Agricultural Impact, Chemical Analysis, Environmental Assessment.

INTRODUCTION

Section One: Theoretical Framework of the Research

The ancient man has been thinking and interested in the study of water since ancient times. Seeing that the state of water resources in the area of the study has been worsened highly because of various sources of pollution and the absence of a plan aimed towards establishing the frames and enhancing the shells of supplying clean water, the researcher has felt the urge to be interested in

exploring the qualitative features of the water of the Diwaniyah River. This water forms the main source of the local community since the study area is located in a dry area whereby rainfall is minimal. In addition, residents do not depend on groundwater as its level of salinity is also too high, and it is not suitable to be used by humans. The research also examines these geographical factors that lead to the constant variations in these characteristics, which is done by gathering of the official data and statistics, laboratory tests on water samples, and the field work to determine the facts associated with the research topic.

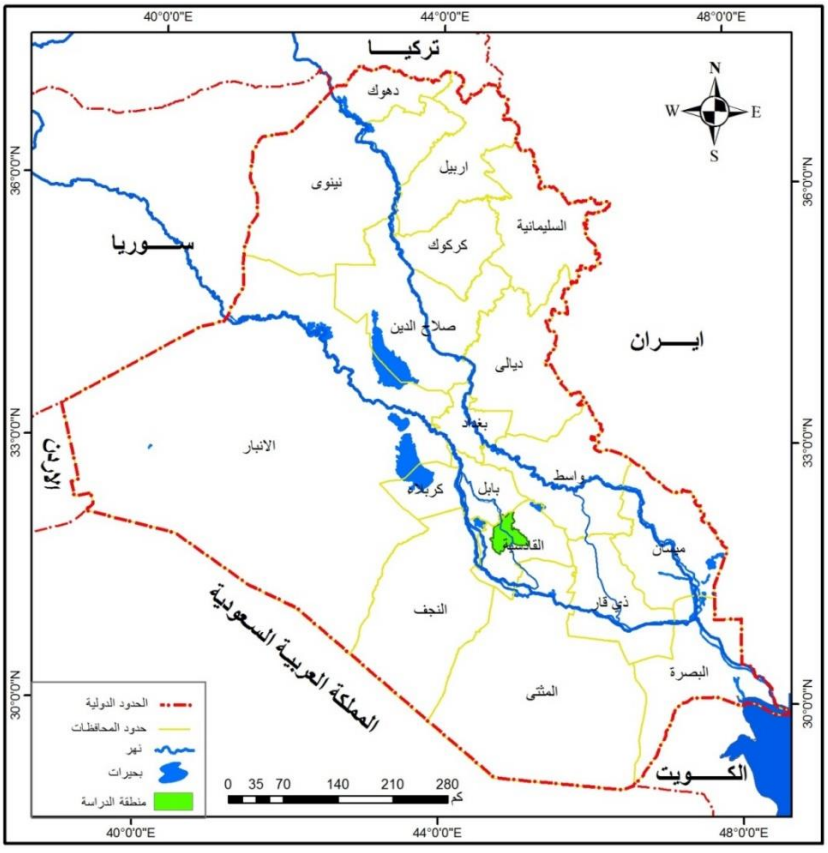
First: The Study Problem. The direct question that can be used to present the study problem can be as follows: What are the qualitative properties of the water of the Diwaniyah River and to what extent can it be used as a source of irrigating agricultural crops in the Diwaniyah district?

Second: Study Hypothesis. Based on geographical aspects (natural and anthropogenic) the qualitative nature of the water in the Al- Diwaniyah River is varied in the study area. Similarly, the appropriateness of the Al-Diwaniyah River water in the irrigation of crops in the area of the study depends on these different characteristics.

Third: Study Objectives. This research paper will explore the physical and chemical characteristics of surface water and assess its feasibility in the production and growth of crops considering the declining quality of water and environmental pollution in the research location with the increase in the population. This also involves the factoring of pollution, caused by agricultural and industrial work.

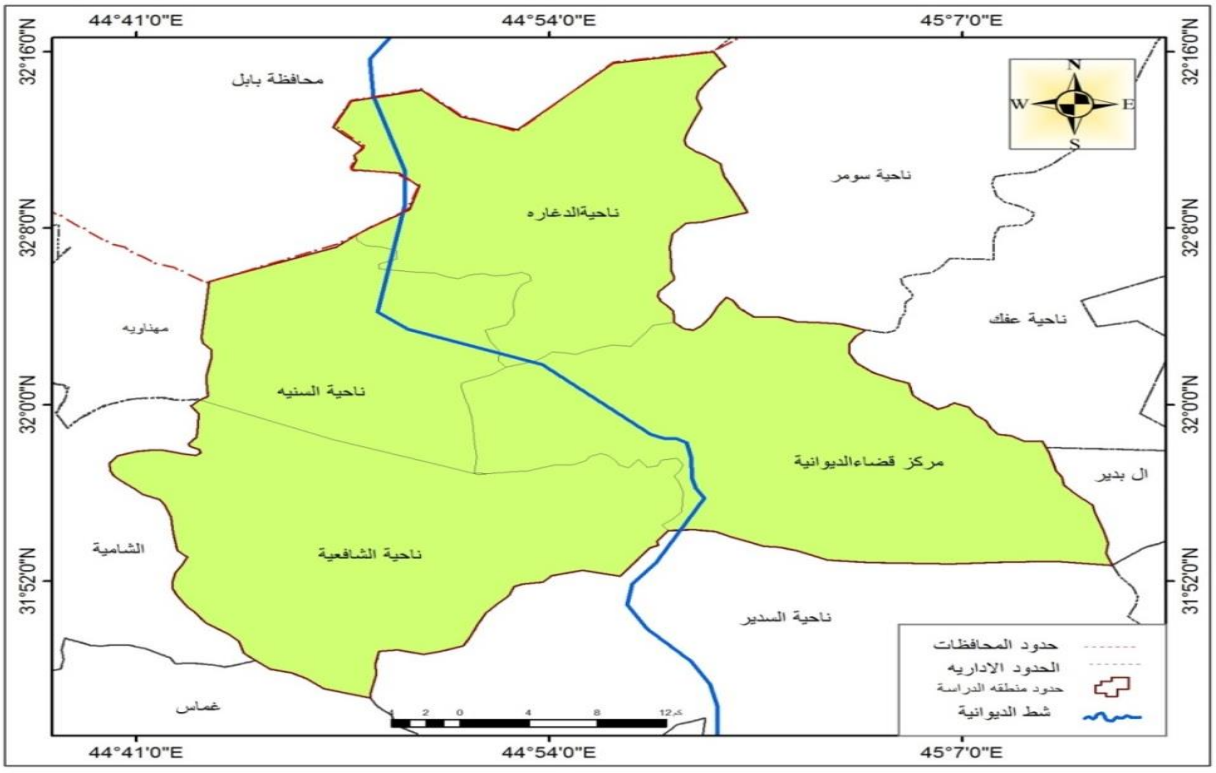
Fourth: Area Boundaries of the study. The area under study lies in the central region of Iraq, in the alluvial plain, between the latitudes 32 o 9 and 33 o 05 North and longitudes 43 o 97 and 45 o 21 East. Map (1) Borders of the study area The study area is bounded to the north by Babylon Governorate, east by the districts of Sumer and Afak, south by the districts of Al-Mahannawiyah and Al-Shanafiyah, and west by Al-Muthanna Governorate and the district of Al-Sudair. Map (2) The area of the study is split into four unites, which are the centre of Al-Diwaniyah District, Al-Daghara District, Al-Siniyah District, and Al-Shanafiyah District. Map (2) The time period of the study is the reflection of the actual state of affairs.

Map (1) Location of the study area within Iraq



Source: Republic of Iraq, General Survey Authority, Administrative Map of Iraq, scale 1/1,000,000, 2019.

Map (2) Administrative Units in Al-Diwaniyah District



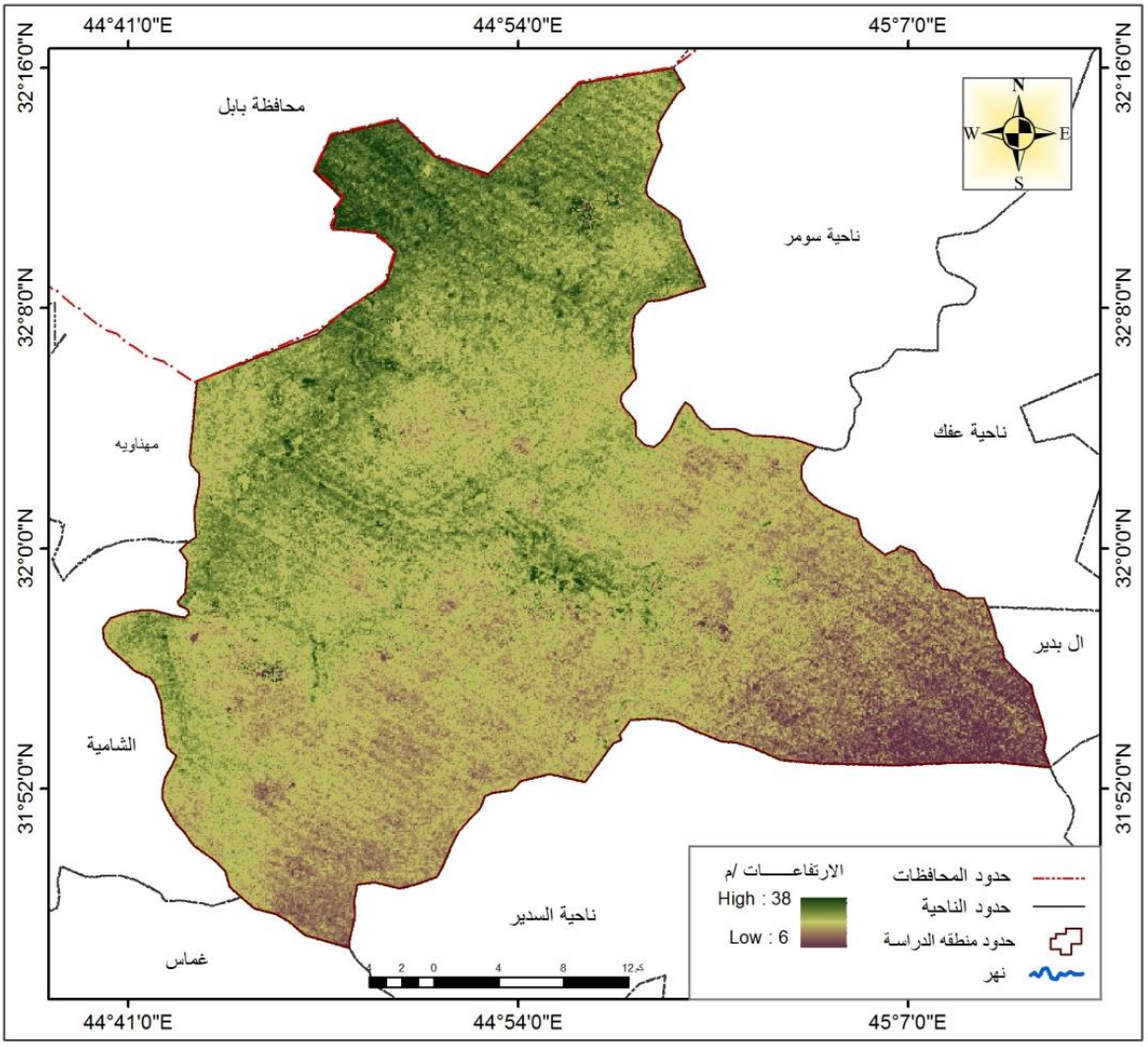
Source: Republic of Iraq, General Survey Authority, Map of Al-Qadisiyah Governorate, scale 1:2,500,000, 2019.

Section Two: Geographical Characteristics Affecting the Water Quality of the Diwaniyah River

The analysis of natural determinants is also an important element in measuring the hydrological health of fluvial systems. The most significant influence belongs to the precipitation regimes and evaporative fluxes as the area of the research falls within the arid and semi-arid landscapes with limited and extremely variable rainfall. In addition to that, the nature of the vegetative cover and the composition of the soils have significant impacts on the water quality of the river Diwaniyah.

First: Natural Features that Influence the Water Quality of the Diwaniyah River: Surface. The region of study lies in alluvial plain of Iraq that is characterized by a rather flat topography. There is a general topography in the direction of the southeast with a topmost spot of about 38 above mean sea level in the northward sectors and a bottom of about 6 above mean sea level in the south and south east areas (see Map 3).

Map (3) of the surface of Al-Diwaniyah district

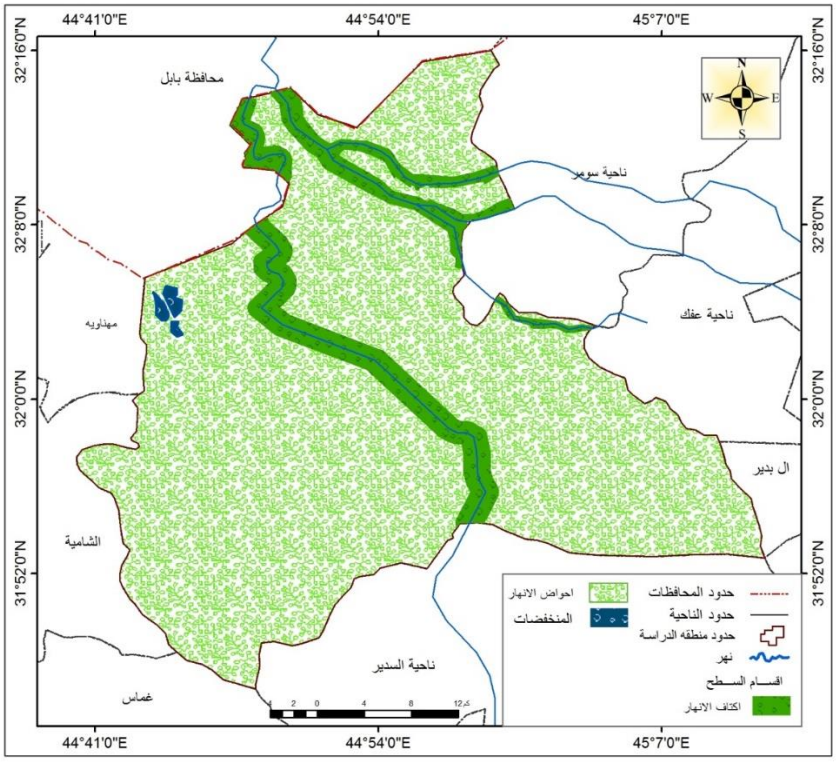


Source: Digital Elevation Model (DEM).

The surface of the study area consists of sediments formed during the Pleistocene epoch. These sediments are riverbank deposits carried by river waters, particularly during the flood season. The quality of the sediments also varies; they are larger in areas close to the riverbanks and smaller and finer in areas farther away1.

The other, larger section of the study area is the river basins, which extend for considerable distances on both sides of the Al-Diwaniyah River (Map 4). These basins are formed from the deposits of the rivers and their tributaries. Their topographic position is lower compared to the riverbanks, and they are characterized by fine sediments deposited by the river far from its course.2

Map 4: Surface Sections in Al-Diwaniyah District



Source: Republic of Iraq, Ministry of Agriculture, Diwaniyah Agriculture Directorate, Agricultural Atlas of Al-Qadisiyah Governorate3, Geographic Information Systems Division, 2019

1. Climatic Characteristics:

The study of climatology, as a discipline, including its various aspects, is one of the major natural determinants that have direct and indirect impacts on the hydrographic features that are prevalent in the area under study.

This statement is especially relevant considering the fact that the region of the research is located in the arid and semi-arid ecoregions, characterized by a limited amount of precipitation and a high level of temperature, which in turn regulate the secondary climatic variables. Accordingly, these variables have a transfigurative impact on the qualities of surface water reserves.

Measurements of temperature at the Diwaniyah meteorological station had a longitudinal range with the highest temperature of 36.02 o C in July and a minimum temperature of 11.5 o C in January (see Table 1). These thermal variations have a direct effect on the concentrations of salinity in the Diwaniyah River.

Table 1 represents the values of precipitation which shows a significant variation with the highest value of 24.1 mm in January- the highest value which occurred and a minimum of 9.01 mm.

Table (1) Characteristics of some climatic elements at the Diwaniyah station for the period (2010-2022)

Month	Average temperature /°C	Rainfall / mm	Humidity %	Evaporation /mm
January	11.5	24.1	69.3	68.21
February	14	15.7	60.2	99.21

March	17.9	11.9	50.9	171.21
April	25	9.01	42.5	252.21
May	31.02	5	32.5	383.21
June	34.1	0	31	511.21
July	36.02	0	30.3	576.21
August	34.99	0	33.6	511.21
September	32.9	0	42.2	381.21
October	27.45	3	42.2	247.21
November	19.01	15.12	58.2	128.21
December	12.1	22	67.9	69.21
Total and Average	24.66	105.83	46.48	3398.52

Source: Republic of Iraq, Ministry of Transport and Communications, General Authority for Meteorology and Seismic Monitoring, Climate Department, Unpublished Data, 2023.

Table (1) shows a variation in relative humidity, reaching its highest value in January at 69.3%), while the lowest value was recorded in July at (30.3%). Evaporation also reached its highest point in July at (576.21 mm).

1. Soil

Soil is one of the most essential natural controls that affect the surface hydrology. The capacity of soil to retain water and mediate percolation of water is determined by its physical properties, which include pore-size distribution, volumetric moisture content, evaporation rates and the general porosity of the soil.

Since the study area is located in the alluvial plain of Iraq, the soil there is of the transported type and consists of fluvial sediments with aeolian sand deposits brought to the regions outside the plain. The soils of this area, then, can be categorized, as per their geographic origin and genesis, as follows:

A- Riverbank Soils:

This kind of soil is mostly found along Diwaniyah and Dagharah rivers and their tributaries. It starts at the northern governorate border, namely, in the Sadr al-Dagharah area and goes all the way to the southern boundary. The soil is ubiquitous across the study land as it was deposited by river Euphrates. Therefore, the accumulation of sediment is the strongest near the river. Therefore, these deposits are characterized by their higher elevation near the river compared to the surrounding land4.

B- River Basin Soils:

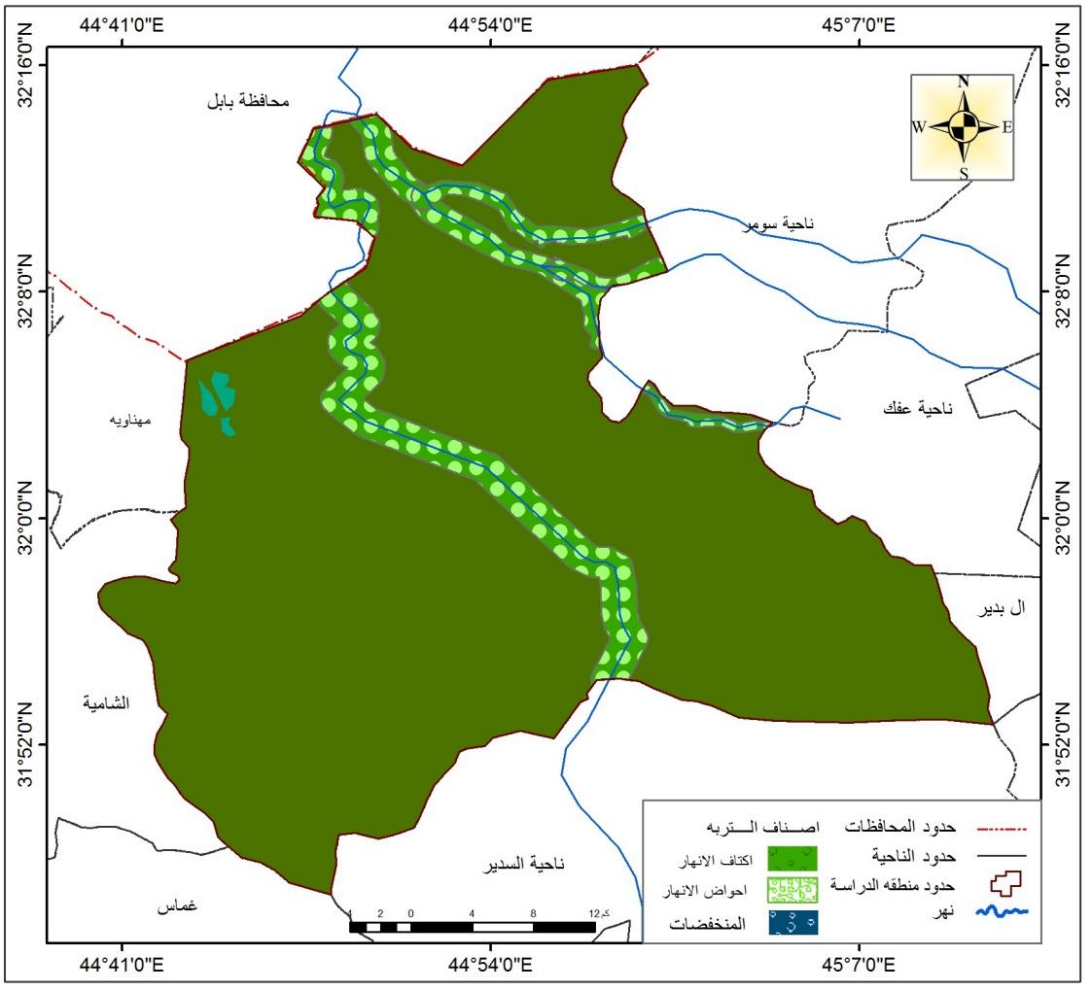
This soil occurs in regions that are far off the river courses, in the transitional regions having both riverbank soils as well as lowland soils. It therefore dominates most of the lands in the district, which were deposited by the alluvial deposits carried by the tributaries of River Euphrates. The river lays the fine fractions on the clay, sands and silt in the low elevations that are way off the riverbanks and these places are about 2-3 metres lower than the height of the riverbank soil.5.

C- Lowland Soils:

Such a type of soil is spread in the northwestern and northeast parts of the district. On the governorate level, the origin of this soil is the low-lying floodplain that was formed due to the depositional processes of the Euphrates River

(Map 5); this soil was formed as a result of frequent floods of the nearby territories 6

Map 5: Soil types in Al-Diwaniyah District



Buringh, Soils Soil Conditions in Iraq, ministry of Agriculture Directorate General of Agricultura Research Projects.

1- Water Resources:

In the region under consideration, the surface water sources (in particular, rivers) are the main source of water, on which the local population depends in their daily activities. These hydrological resources branch out to two tributaries, namely the Diwaniyah River and the Dagharah River7.

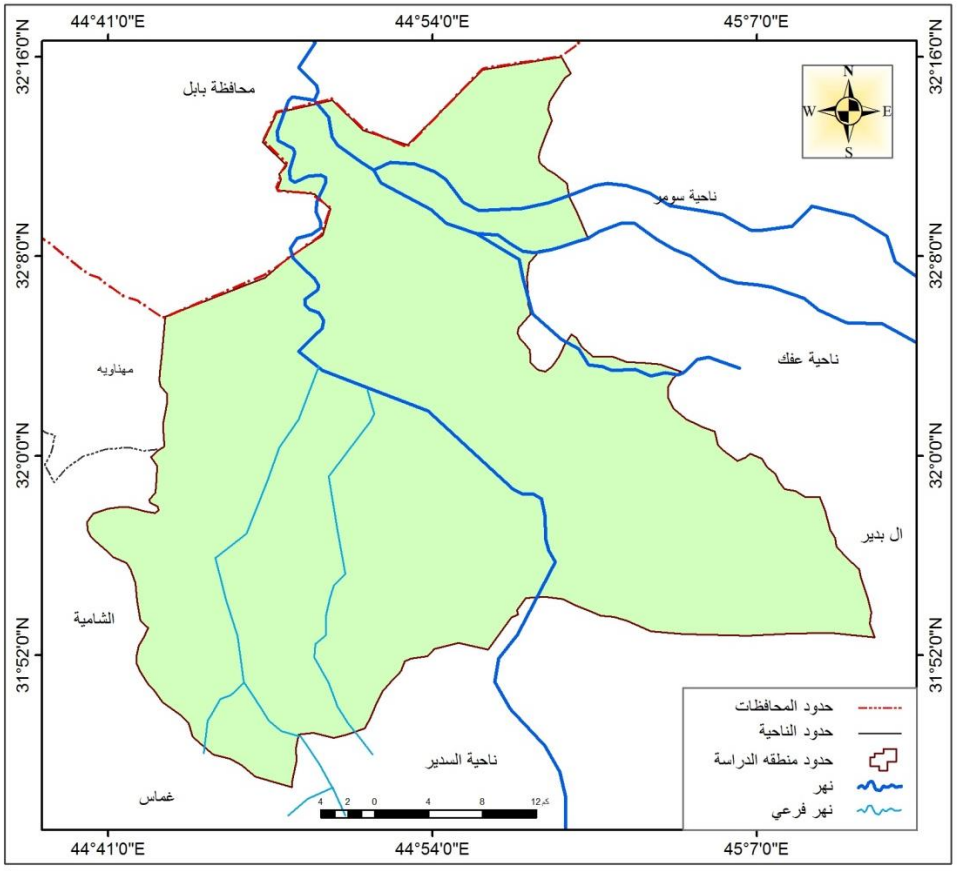
a- Diwaniyah River:

The Diwaniyah River, which has the headwaters of the Hindiya Barrage, joins the study area in the lower part of its northward flow of the Sadr Regulator, where it supplies a number of subsidiary streams8.

b- Dagharah River:

The Dagharah River separates the Diwaniyah River at kilometer marker 103 on its left bank and flows to the northern parts of the area of study with a discharge of 64m3/s observed. However, its present working flow is lower than 14m 3 s minus one9.

Map (6): Extension of the River Network in Diwaniyah District



Source: Al-Qadisiyah Governorate, General Directorate of Water Resources, Diwaniyah Branch, G.I.S. Division, Water Resources Map and Irrigation and Drainage Projects for 2019

1. Natural Vegetation:

Natural vegetation is one of the most critical biophysical factors that dictate the hydrology of surfaces in different geographic locations in the globe. It has an effect on hydrologic pathways, including the drainage network and the kinetic regime of water precipitatively sourced in fluvial systems. Moreover, it provides a protective coating against the eruption forces against the soil matrices and the lithologic substrate. The ability of vegetation to support the water resources further goes to the aspect of reducing the severity of floods, which is made possible by the retardation of sediment movement into the reservoir, irrigation conduits, and riverine channels11.

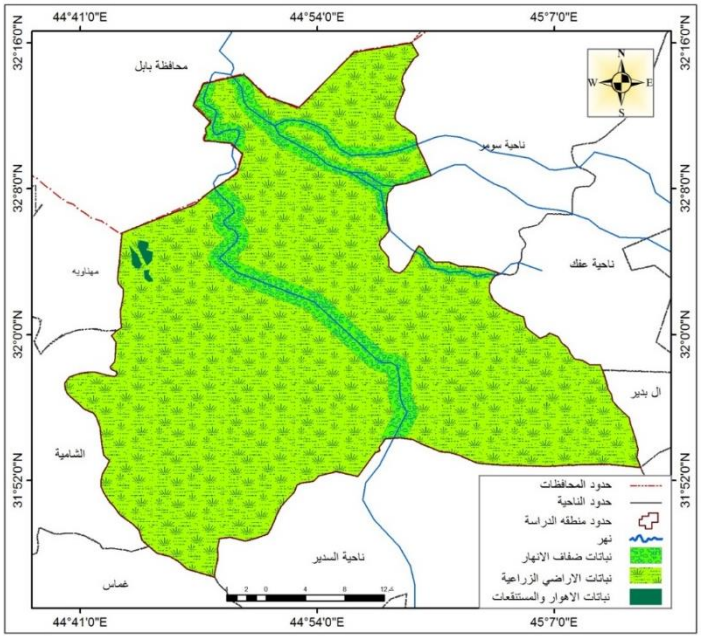
The root structure of many plant taxa permeates the soil profile thus promoting stickiness between the particles of the soils to prevent the detachment of rock material by the pluviational or aeolian activities. As a result, the volumetric flux of the sedimentitious material to fluvial corridors is significantly reduced. The vegetation of significant density creates a great impedance on surface runoff primarily because of its fibrous root systems which aid higher infiltration rates; this process increases the percentage of precipitation infiltrating into underground layers12.

Riparian vegetation is prevalent in the study area being examined. These groups inhabit the alluvial margins in the form of arboreal, shrubby and herbaceous, achieving compact structural arrangements as a result of the habitually wet hydric regime. This riparian vegetation has a realised retarding effect on the propagation velocity of water flowing longitudinally through the irrigation channels as well as the neighbouring streams networks. One of these, especially important, is Escherichia (esparto grass) which spreads by means of sexual propagules as well as asexual rhizomal growth, and commonly forms extensive stands along floodplains, irrigation ditches, and soils with high moisture content14.

The species that are found in wetlands, e.g. the

marsh and swamp flora, are mostly located in alluvium marsh bottom, waterlogged zones and drainage structures in the basin. The type of taxa that are representative of such environments include items like reeds (*Phragmites spp.) and papyrus (*Cyperus papyrus) which are often found in agricultural areas - both summer and winter crop rotation - because of their ability to survive the high moisture indices. The vegetative community in winter crop is often based on leguminous and grassy species, and they are the primary weed species in the cultivated plots15.

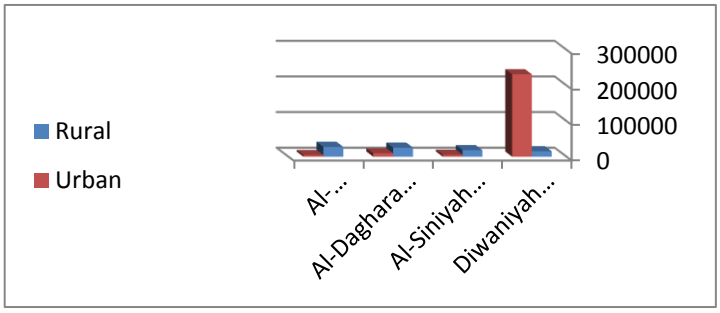
Map (7) Identifies the natural vegetation covers of the Al-Diwaniyah District.



Administrative Units	City	The countryside	Total
Al-Siniyah Sub-district	231267	15372	246639
Al-Daghara Sub-district	5402	18296	23698
Al-Shanafiyah	9458	25470	34928
Sub-district	4633	27528	32161
Total	250760	86666	337426

Source: Republic of Iraq, Ministry of Planning and Development Cooperation, Central Statistical Organization and Information Technology, 2019 General Population Census Results for Al-Diwaniyah Governorate.

Figure (2) Population Distribution by Environment (Urban-Rural) in the Study Area



Source: Based on Table (3)

2. Agricultural Activity:

Agriculture is one of the largest consumers of freshwater resources in the world, with irrigation practices taking a maximum of 70 ¯ □ comparing with that in the world. This percentage in most developing countries is even higher, at about 95��anean emphasis has been put on the fact that the sector depends heavily on water. On the basis of our study area, approximately 90 per cent of the water available to the agricultural sector is used to irrigate the cultivated lands of approximately 483396 dunams16 (see Table 3). This footprint of irrigation is spatially heterogeneous, which is depicted in Figure 3.

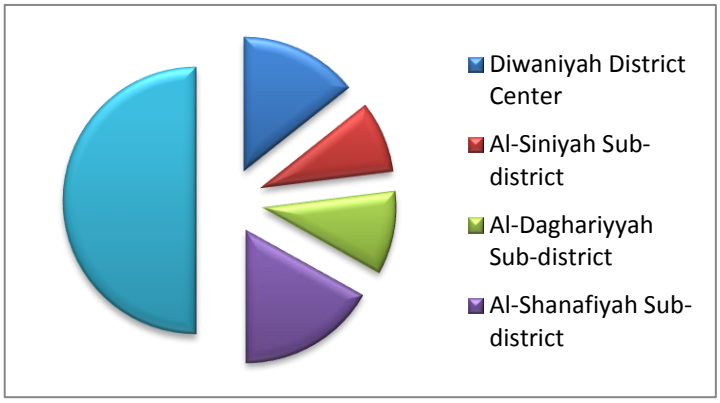
Besides, the hydrologic quality of the Diwaniyah River is significantly affected by agricultural practices. Due to the application of chemical fertilizers, pesticides, and insecticides, there is a set of anthropogenic pollutants that are carried by the river system. A considerable proportion of these agrochemicals dissolve in irrigation water and this causes excess run off that flows into surface water or ground water which later flows into the river which also increases its pollution load17.

Table (3): Cultivated Areas in Al-Diwaniyah District

Administrative Units		Cultivated area/dunum	%
Al-Siniyah Sub-district		138500	28.7
Al-Daghara Sub-district		84000	17.4
Al-Shanafiyah		97846	20.2
Sub-district		163050	33.7
Total		483396	100

Source:Directorate of Agriculture, Al-Qadisiyah Governorate Statistics Department, Unpublished Data, 2019

Figure (3) Cultivated Areas in the Study Area



Source: Based on Table (3)

3. Agricultural Activity:

One of the largest consumptive demands of the hydrologic budget in the world is agriculture, where irrigated arable lands comprise up to seventy percent of all water withdrawals. This percentage becomes significantly higher in low-income economies, up to ninety five percent of the total water consumption.18 In the frames of the current study area, nearly ninety percent of the entire water resources provided to agriculture is devoted to the irrigation of the plots of cultivated lands, which objectively occupy about 483,396 dunams as can be seen in Table 3. Such irrigation demand however is not distributed uniformly across the study area but rather it is heterogeneously distributed as shown in Figure 3.

In addition to this, the agricultural activities have a significant negative impact on the water quality of Diwaniyah River by using synthetic fertilizers, pesticides, and insecticides. Such agro chemicals move into the river system through the riverine system, and a considerable percentage of them becomes soluble in the irrigation water.19 As a result, when the excess water infiltrates into the surface reservoirs or permeates into the water systems, the same water later enters the river and is released into these water systems thus causing incremental pollution of the river.

Table (3) Cultivated areas in Al-Diwaniyah district

The Total	Construction Industry	Petrochemicals	Textiles and Clothing	Food	Industry
19	9	5	1	6	Preparation

Source: Satellite imagery of the study area from the Landsat LCI 8 satellite of the USGS Earth Explorer.

Second, the human factors affecting the quality of water in the Diwaniyah River are outlined below:

The anthropogenic factors that support water quality in the Shatt al Shamiyah are listed as follows:

1. Population:

This aspect forms one of the main causes of ecological strains of the water system especially since the Diwaniyah district lies in an arid and semi arid terrain with low rainfall and high temperature. In addition, there is a high percentage of the population located in the riverine strip and this together contributes to the volume of contaminants released to the water. Table (2) shows the population distribution within the study region as per residential environment. The urban sector contained 250,760 inhabitants, and the rural contained 86,664 inhabitants. These numbers were distributed differently, with the highest urban population density (231,267 residents) in the central part of Al-Diwaniyah District, and the largest rural group (27,528 residents) in the Al-Shanafiyah sub-district (Figure 2).

Section Three: Characteristics of the Diwaniyah River Water and its Suitability for Irrigation

The need to investigate the physical and chemical properties of irrigation water can be explained by the fact that salts, ions, and cations are variable in nature and cause serious agronomic problems in the study area. This section, therefore, explains about the sampling of the samples that were collected in the strategic locations along the Euphrates River and its tributaries (see Map 12) to be analyzed later in order to know the suitability of the water to the growth of the field crops.20 These properties affect the number of important criteria such as net cultivable area and yield potential determination. These characteristics are divided into physical and chemical characteristics as the following.

First: Physical Properties:

The water quality is mainly controlled by the nature and nature of the origin of water. Water of high quality is usually derived out of clean and healthy sources and besides, it is supposed to be colourless, tasteless, and odourless, but in the event that environmental circumstances or anthropogenic factors change its composition and reduce its quality. 21These properties could be expounded in the following way:

The mixing processes involved in the movement of water and the percentage of salts available to it also control the river temperature, which is also affected by the ambient temperature of the atmosphere. The seasonal change in the average temperature of Diwaniyah River has been shown in Table 5, the maximum average temperature (34.2 -1 0 C) was found in July and the lowest (10.3 -1 0 C) in January.

The conductivity of electricity is spatially heterogeneous at the sampling sites. Maximum conductivity (around 3465muS cm -1) was recorded in July at location S4 with the lowest being conductivity (970muS cm -1) recorded at the location S2 during winter (Table47).

There is also variation of total dissolved solids (TDS) in the waters of the Al-Diwaniyah River across the study area. As Table 47 shows, the concentration of TDS was the lowest in January and the highest concentration of TDS (around 602 mg/L -1) was measured in July, with an intermediate at 421.75 mg/L -1.

Table 5 also indicates that there are marked differences in the pH of the waters of the Al-Diwaniyah River. The alkaline range of 7.7 was the maximum pH which was registered in July and likewise the lowest pH (7.2) was measured to be in July22.

1-Chemical Characteristics:

Table 5 shows that there is a seasonal change in magnesium (Mg 2 +) concentration in the Diwaniyah River waters. January mean concentration was 46.025 mg L -1 and July had the maximum concentration of 28.4 mg L -1.

Table (5) Qualitative Characteristics of the Diwaniyah River Water

Data	S1	S2	S3	S4	Average

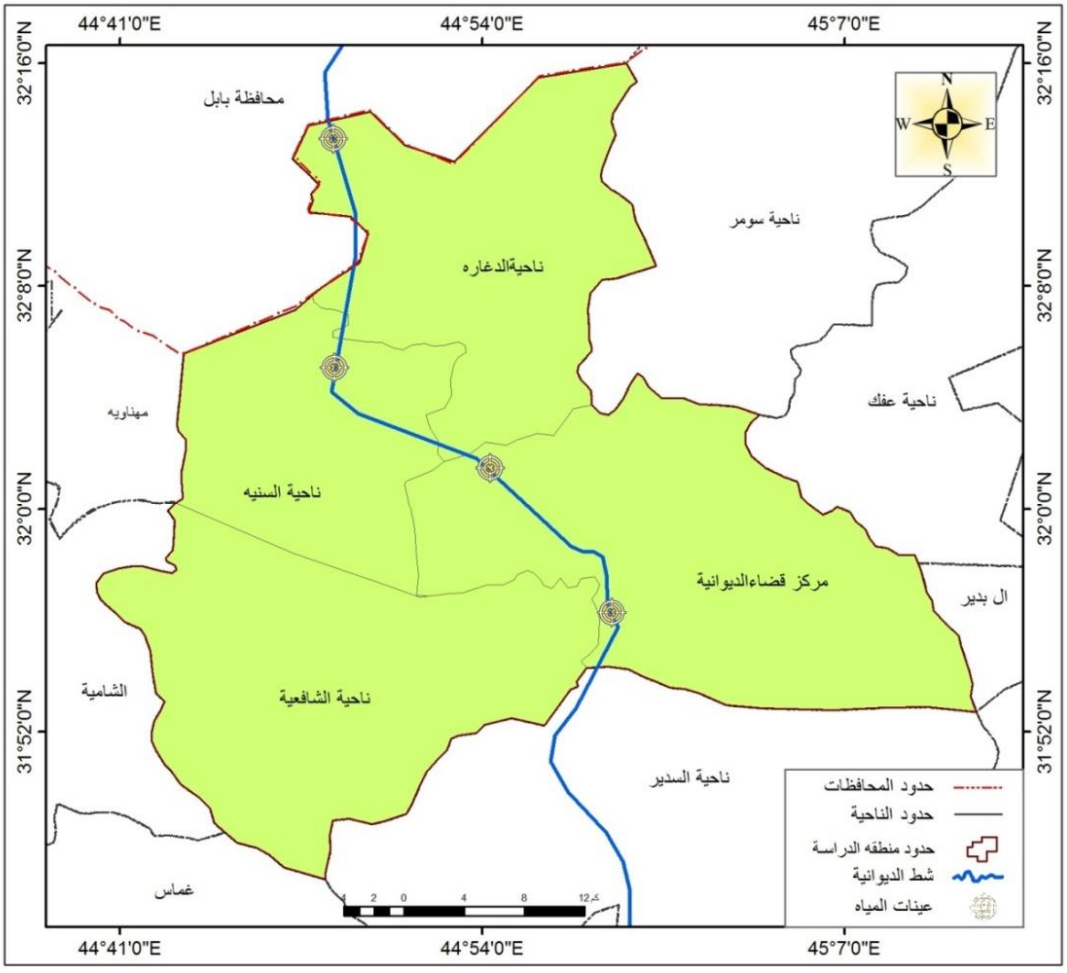
Heat	January	10.3	12.1	11.9	12	11.575
	July	32.1	34.2	33	31.21	32.6275
electrical connection	January	1250	970	1390	2499	1527.25
	July	1573	1081	1571	3465	1922.5
Total dissolved salts (TDS)	January	410	315	399	563	421.75
	July	654	571	583	600	602
PH	January	8	7.8	7.8	7.7	7.825
	July	7.7	7.2	7.6	7.5	7.5
Na+1	January	80.9	67.1	69.9	80	74.475
	July	93.5	77.4	88.9	90.1	87.475
Mg+2	January	34.9	34.9	54.7	59.6	46.025
	July	33.8	16.9	30.9	32	28.4
Ca+2	January	122	72.3	122	125	110.325
	July	129	87	110	97	105.75
K+1	January	1.9	1.2	2	2.8	1.975
	July	2.9	2.3	2.9	3.3	2.85
So4-2	January	445	500	501	431	469.25
	July	521	679	753	922	718.75

Source: Based o: Republic of Iraq, Directorate of Environment in Al-Qadisiyah Governorate, Chemical Laboratory, Unpublished Data, 2019.

Directorate of Environment in Al-Muthanna Governorate, Chemical Analysis Laboratory, 2019. Laboratory Analysis Results.

The minimum level of calcium was recorded at site S 2 in the waters of the Al-Diwaniyah River and was 72.3 mg/L in January. On the other hand, July recorded the highest value with site S1 recording a concentration of 129 mg/L. The other monitoring sites had concentrations within this range23.

Map (8) Water Sample Sites in Al-Diwaniyah District



Source: Based on Table (5).

The concentration of sodium ions was different in some places. The lowest concentration was at location (S2) in January and was (mg/L). The maximum concentration was detected at location (S1) where 93.5 mg/L was registered in July. The other sites registered in between these two values.

Concerning the sulfate concentration in the Al-Diwaniyah River, the minimum concentration was observed in January and stood at around 431mg/L, the highest concentrations were observed in July where it was around 431mg/L.

The diwaniyah river water and its suitability in agricultural practice in the Diwaniyah district.

The decision about the appropriateness of the Diwaniyah River water in the irrigation of crops is determined by a number of variables among them the temperature, humidity, wind, and salt content of water. Moreover, the soil characteristics like the texture, porosity, salinity content and even the kind of crop that is being irrigated in regard to its sensitivity to salt are also factored in. There are a few significant indicators, which are applied according to the common parameters, to evaluate the appropriateness of water intended to be utilized in irrigation and to estimate the risks of it.

By the requirements of the American Salinity Laboratory, which categorizes the quality of water according to the overall presence of dissolved salts and electrical activity and in comparison to the study results, it was discovered that Diwaniyah River water at most of the points belongs to category (C3). The category is capable of developing salt-tolerant plants on the well-drained soils provided that there is a proper system of drainage and soil leaching. Nevertheless, location (4) at summer would be in category (C4) where electrical conductivity was at 3465 micromoles/cm.

Table 6. Water irrigation suitability based on the classification of the US Salinity Lab in terms of the total salt content (TDS) and an electrical conductivity value.

Water Suitability.	Total dissolved salts (mg/L)	Electrical conductivity micromoles/cm	Water classification
The water is suitable for most plants and most soils, with a very low probability of soil salinity.	Zero160 -	250 -100	C1little salinity
The water is suitable for salt-tolerant plants with continuous soil leaching.	480-160	750 -250	C2 - middle salinity
The water is suitable for salt-tolerant plants on well-drained soils, provided there is a good drainage and leaching system.	1440-480	2250 -750	C3 -high salinity
The water is suitable for highly salt-tolerant plants on permeable, well-drained soils with strong salt leaching.	3200-1440	5000 -2250	C4 -very high salinity

Source: Kamel Hamza Felfel and Ayed Jassim Al-Zamili, "Groundwater Characteristics Variation in the Western Plateau of Najaf Governorate Using Geographic Information Systems," Journal of Geographical Research, Issue (19), 2012, p. 236.

Comparing the findings of the tests carried to examine the total dissolved salts at the locations of study, all the samples are within the allowable range as per the American Salinity Laboratory classification, Table (6). They have their highest concentrations of (421.75 mg/L) in the winter and (602 mg/L) in the summer, Table (5).

When the test results are compared with the Islamic Educational, Scientific and Cultural Organization (ISESCO) standard (Table 7) it is found that the electrical conductivity of the Al-Diwaniyah River water is within the existing limits as stipulated by ISESCO with the exception that site (4), the conductivity of the water was (3465

uS/cm) which is (Table 5). The element (T. D. S) meets the standards of ISESCO criteria of suitability to the site with respect to irrigation (Table 7). But the calcium (Ca) element is not also suitable in all of the investigated locations, as the level of this element was reached (110.325mg/L) in winter and (105.75mg/L) in summer (Table 5). Hence, it falls out of the allowed limits as per ISESCO standards that is (0 20 mg/L). Concerning magnesium (Mg) it is seen appropriate to be used in irrigation as per the Islamic Educational, Scientific and Cultural Organization (ISESCO) standard in all places except places (3) and (4), which are inappropriate (Table 7) to (54.7 59.6 mg/L) respectively (Table 5).

Water of the Shatt al-Diwaniyah based on ISESCO standard of sulfate (SO4) is unsuitable in all the investigated sites to be irrigated in the two seasons as its value went between (431-922 mg/L) (Table 5). As such, it is outside the acceptable parameters, which is between (0 -200 mg/L). At the same time, Table (7) indicates that sodium (Na +1) in the Shatt al-Diwaniyah water cannot be used in irrigation compared to the recommended level of (0- 40 mg/L) by ISESCO. Nevertheless, the concentrations of potassium (K) in the water in the sites under study are not appropriate in irrigation activity as compared to the standard stipulated by the Islamic Educational, Scientific, and Cultural Organization (ISESCO), which is between 0 and 2 mg/L, excluding site (1), (2), and (3), at the winter season.

The pH content of the water in all locations investigated is good to use in irrigation as compared to the main standard by ISESCO that goes with a range of 6 to 8.5.

The water samples in the laboratory tests confirmed that the waters of Diwaniyah River suffer deterioration in their physical as well as chemical properties that have adversely affected the crops planted in the study region. Physical and chemical features (qualitative) of surface water at the study area is different in each place and season. This is because of the natural factors and also the human factors which are the domestic, agricultural and industrial wastes.

The concentration of dissolved salts in the locations under study was also determined to be falling within the acceptable levels of concentration as provided by the American Salinity Laboratory categorization. Potassium (K), sodium, and sulfate (SO4) concentration levels in the waters of the examined places are not suitable to be used in irrigation. The field and laboratory analysis outcomes revealed that the waters of Diwaniyah River have a severe temperature increase peaking in July (34.2 -1 C) and lowest in January (10.3 -1 C). This important temperature difference is one of the factors that led to the alteration in chemical as well as physical properties of the water.

The elevated temperature had adverse effects on the electrical conductivity, and it was equivalent to 3465 uS/cm. The high value means that the water is salty and poor in its quality to conduct irrigation. By comparing the findings with the standards of Islamic Educational, Scientific and Cultural Organization (ISESCO), the concentrations of certain chemical elements, including pH, potassium (K), sodium (Na), and sulfates (SO4) were higher than the allowable levels of the particular elements in irrigation thus the water in the study areas was not fit to be safely used in agriculture.

The paper revealed that the total dissolved solids (TSS) in the waters of the Shatt al-Diwaniyah River was not exceeded by the allowed range of the classification of the American Salinity Laboratory. That means that the pollution is associated with certain factors and not the general rise in the total salinity. Geographical information systems (GIS) maps have shown the existence of spatial differences in the levels of pollution along the river, which showed the influence of human, agricultural, and industrial activities along the riverbanks.

The outcome indicates that the release of untreated wastewater and agricultural and industrial effluents to the river is a major cause of pollution that results in the concentration of harmful components in irrigation water. Recommendations: Before the water is used in irrigation, treatment plants should be set up on the Diwaniyah River to minimize salt and other harmful elements levels and, consequently, enhance water quality. Periodic (monthly or quarterly) check up of water quality of the river through laboratory samples and compare the findings with weather and climate data to effectively establish the sources of the changes. Improve interdepartmental coordination between the environmental, agricultural, and water

resources department in order to check the sources of pollution and impose environmental regulations on the concerned facilities. The research suggests the implementation of GIS as one of the major monitoring and tracking tools of spatial change in water quality and mapping of environmental threats. The awareness campaigns ought to be conducted to inform the general population on the risks of irrigation with polluted water and the effects on the soil, crops and human health. Modern irrigation methods should also be promoted by these programs in order to save on water and curb pollution. One can recommend to increase the range of research to cover other seasons and compare the findings in the long term in order to see the overall pollution patterns and peaks. The factories and farms near the river should be put under strict monitoring to ensure that they do not release their untreated wastewater to the Diwaniyah River. Awareness creation to the general population especially the farmers about water usage and conservation should be considered. Prior to the release of water into irrigation, treatment plants need to be set up on the Diwaniyah River to decrease the amounts of salt and other harmful elements and enhance the quality of water. Laboratory sample studies should be carried out regularly (monthly or quarterly) to monitor the quality of water in the rivers. Weather and climatic data should be correlated with the results to be able to define the causes of changes. Firm laws and regulations are required to be passed against dumping of agricultural, municipal and industrial waste in the river water network.

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