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Impact of the sewage disposal from Kut City on the surface water of Al-Shuwaija Marsh, Iraq

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ABSTRACT

This study aimed to evaluate the quality of the water in the Al- Shuwaija Marsh in Wasit province, the Iraq. The marsh was suffering from pollution due to salt accumulation and drainage of a large quantity of untreated sewage from the wastewater treatment plant in the Kut City discharges from an outlet approximately 12 meters above sea level at point 1. Environmental problems at the marsh increase in dry weather throughout the summer season. Eleven sites were selected at different locations for two periods (November 2019 and July 2020). Samples were collected from each site and then tested experimentally. Tests included dissolved oxygen (DO), biological oxygen demand, electrical conductivity (EC), total suspended solids (TSS), turbidity, total dissolved solids (TDS), total hardness (TH), and acidity (pH). According to the results, the locations closest to the sewage treatment facility (points 1, 4, 2 and 3) exhibited the highest levels of contamination since they got the most wastewater, especially during the receding season, where the concentrations of BOD (180 mg L^{-1}) and DO (4.6 mg L^{-1}) exceeded the permissible limits for water specifications.

Keywords: Environmental assessment, Al- Shuwaija marsh, Geographic information system, Pollution.
Article type: Research Article.

INTRODUCTION

Pollution of Iraq's marshes remains a severe threat despite recent efforts, where climate change, lack of water revenues and the release of pollutants in water sources have contributed significantly to the pollution of large parts of the marshes (Hassan 2010). Due to the large quantities of chemicals utilized in our everyday lives, river water quality monitoring and management have become more difficult in recent years (Abed *et al.* 2020). Water availability, pollution prevention, and optimizing water use have all received increased attention in recent years (Hussein & Abed 2020; Hussein *et al.* 2022; Bostubayeva *et al.* 2023). Drought may exacerbate the problem of water contamination. Lower water levels lead to an increase in the concentration of undesirable pollutants (Fazaa *et al.* 2021). Part of the water evaporates from the reservoirs as a result of the noticeable rise in temperatures in light of climatic changes (Zhao & Gao 2019). For future generations to satisfy their water demands in the face of climate change and environmental contamination of surface waters, sustainable integrated water resource management is also required (Al-Rubaie & Al-Musawi 2019). The appropriate solution to maintain the quality and levels of water required ensuring the operation, hence continuous use of water is comprehensive planning and management (Asaad & Abed 2020). As a result of extensive dam building, a lack of available water sources, the effects of climate change, and the inability of these marshes to generate an outflow during low-flow times, the water quality in these areas is deteriorating (Al-rikabi & Abed 2021). In order to increase the amount and quality of water entering the downstream countries of a shared watershed, attention should be paid to water resource management and the necessity to enforce existing international bilateral agreements and implementing the Water Framework Directive (Dunca 2018). In reality, the water pollution index proved effective in giving managers and

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decision-makers the data they needed to keep rivers in good. The study area suffers from neglect, pollution and non-use of stored water. The areas close to the sources of pollution become more polluted and gradually decrease away from the source (Ospanov *et al.* 2020). Shuwayja marsh receives the majority of its water supply from runoff from the mountains on both the Iranian and Iraqi sides of the border during wetter years (Hilo 2013). Part of the water stored in the Shuwaija marsh is discharged to the Tigris River through the Nazim um Al-Jiri with a discharge of up to 50 m^3 sec^{-1} (Azzubaidi 2020). Large quantities of wastewater are discharged from the wastewater treatment plant on the left side of Kut City, which is located 6 km from the Shuwaija Marsh (North 3607905.02 m N 586985.97 m E), up to (35,000 m^3 per day) inside the Shuwaija Marsh at Point 1, and is expected to exceed 50,000 m^3 per day as a result of the increase in population density by connecting additional pumping stations to the treatment unit.The main aim of the current study was to assess the wastewater disposal effect from Kut City on the water quality of the marshes, establish a database for the water quality of Al- Shuwaija Marsh, and contribute to identifying the best water quality monitoring locations. Moreover, recommendations for the mitigation of the impacts and risks to reduce pollution will be provided.

MATERIALS AND METHODS

Study area

Al-Shuwaija located north of Kut, 10 km (Northing 3615031.00 Easting 585850.00), is a natural depression that extends parallel to the Tigris River (with an area of 250 km^2 and a ground level of 14 m above sea level. The marsh is filled with rainwater and torrential rains that reach from the east through the Galal Badra and Tursaq rivers established from the north during the rainy season which begins in January and reaches the highest reservoir in March (Al-Shamaa & Ali 2012). The water leaving the treatment plant in Hor Al Shuwaija at point 1 is dumped with specifications that are not acceptable according to environmental laws to preserve water resources. Fig. 1 shows where the research area is situated within Wasit Province.

Sample collection

Al- Shuwaija Marsh water samples were collected monthly from November 2019 through July 2020 from eleven predetermined sites. The grab sampling apparatus was used to collect these samples. These samples were kept in an incubator to be tested as soon as possible after collection in the environmental laboratory. The typical sampling time frame was 7:30 AM to 11:30 AM.Water samples were taken at water depths ranging from 20 to 40 cm below the water surface. Sampling was performed in accordance with guidelines established by the American Public Health Association (APHA) in 1998. Table 1 illustrates the information of the sampling sites in the study area. Laboratory test results of water samples included BOD, DO, TH, pH, EC concentrations, TDS, TSS, Turbidly, and water temperature, as well as measurements of water depths at these sites. Fig. 2 indicates sampling locations.

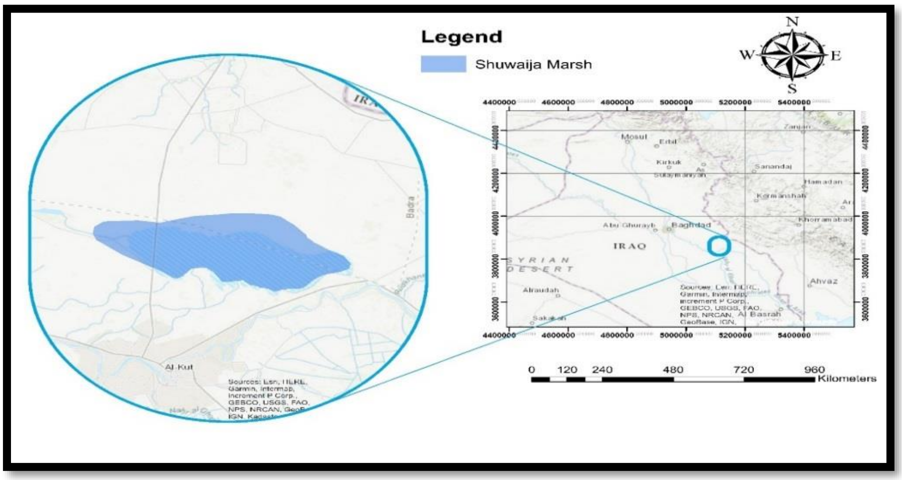

Fig. 1. Location of the study area (Al-Shuwaija Marsh).

Table 1. Location information of sampling point in Al-Shuwaija Marshes.

No. of Sample	Location		Elevation m s a*	Notice
	Northing	Northing		
1	3615031.00	585850.00	14.15	W.T.P
2	3617038.42	584463.43	14.5	2500 m From point 1
3	3616844.19	587456.63	14.7	2500 m From point 1
4	3615271.63	589561.40	14.26	2500 m From point 1
5	3619029.20	580464.33	15.13	5000 m From point 1
6	3620469.22	584870.54	15.07	the midpoint between 10 and 11
7	3618943.00	588930.00	15.2	5000 m From point 1
8	3616498.92	593182.99	14.35	5000 m From point 1
9	3618365.00	598217.00	15.5	5000 m From point 1
10	3622863.00	592752.00	15.65	Entrance to Al-Shuwaija from the side of the Galal River
11	3620745.00	575801.00	15.55	Entrance to Shuwaija from the bridges on (Badra- Kut) Road

* The bed levels of Al Shuwaija were extracted during the drought period using a GPS.

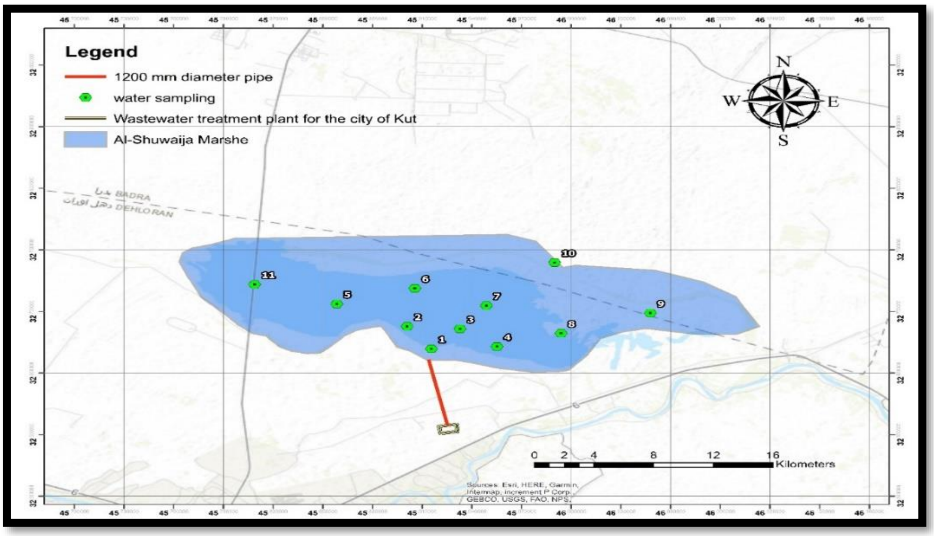

Fig. 2. Location of water sampling in Al-Shuwaija Marsh.

Geographical Information System (GIS) mode

There are several domains, such as engineering and environmental science, where GIS might be used to help solve environmental problems (Nagalakshmi *et al.* 2016). The water quality in the research region was analyzed spatially using a spatial analysis approach implemented in GIS software version 10.8 (Abbas & Abdulameer 2020). The IDW (inverse distance weighted) and Spline tools are deterministic interpolation method and Kriging are based on a statistical model (Huchhe & Bandela 2016). To pinpoint likely locations for poor drinking water quality, a GIS was used to generate IDW maps depicting the geographical distribution of several physical and chemical characteristics (Raikar & Sneha 2012). Inverse distance weighted interpolation was used to calculate the water quality index by extrapolating data from sampling locations. Spatial data, including geographic data, GIS data, maps data, spatial geometry data, and location data, were input in order to analyze, display, and produce geospatial maps (Kraak & Ormeling 2020). The water quality condition scenarios were better understood thanks to continuous surfaces generated using GIS spatial analysis (Tong & Chen 2002). Using GIS tools, the obtained data may be structured in a way consistent with a scientific procedure, making it straightforward to display in a spatial format (Al-Musawi *et al.* 2018). In combination with conventional techniques, GIS modeling may be a valuable tool since it is less costly and provides a complete geographical resolution of the research location. This approach does not extrapolate beyond the highest and lowest values and provides precise and comprehensive data within the observation zone (Vasistha & Ganguly 2022). The research area point map (in KML format) was imported into a GIS application, followed by the sample results (in Excel format), and finally, a spatial analysis was performed for each test.

RESULTS

The data obtained through the results of tests in laboratories and field measurements are presented through the spatial analysis of the GIS program, which will help in obtaining a clear view of the quality of the Shuwaija Marsh during the periods of decline and inundation, in addition to a statement of the impact of the sewage treatment plant and the discharge of Um Aljury. As shown in Tables 2 and 3, the mean values for two different periods were based on physical, chemical, and biological water sample parameters tested in a laboratory (wet weather). Based on the results of this research, we may propose the following framework for discussing water quality parameter concentrations:

Table 2. Average physical, chemical, and biological properties from laboratory tests of water samples for the period (wet weather).

No. of Sample	BOD (mg L^{-1})	DO (mg L^{-1})	TH (mg L^{-1})	pH	EC (μS cm^{-1})	TDS (mg L^{-1})	TSS (mg L^{-1})	Turbidity (NTU)	Depth (cm)	Water Tem (℃)
1	180	4.6	620	7.1	7375	4682	100	42	180	20
2	65	5.21	600	7.4	5400	3654	75	32	150	20
3	64	5.4	590	7.3	6275	3250	94	38	130	21
4	74	6	585	7.2	5460	3682	86	35	174	22
5	45	6.1	690	7.8	3850	1900	65	25	87	21
6	36	6.1	690	7.9	4240	1850	66	27	93	22
7	52	6.3	730	7.6	4500	1980	54	21	80	23
8	54	6.4	710	8.0	3375	3150	40	19	165	24
9	39	6.9	790	7.5	2250	4200	24	8	50	25
10	30	7.2	800	7.9	5030	1875	72	31	35	25
11	21	7.2	750	7.7	4500	1760	70	29	45	20
The total water storage of the marsh							(M^3)		450000000	
Outlet (Um-Aljury)							m^3/sec		10	
Water treatment plant sewage							m^3/sec		1	
Galal Badra							m^3/sec		18	
Tursaq							m^3/sec		12	

Table 3. Average physical, chemical, and biological properties from laboratory tests of water samples for the period (dry weather).

No. of Sample	BOD (mg L^{-1})	DO (mg L^{-1})	TH (mg L^{-1})	pH	EC (μS cm^{-1})	TDS (mg L^{-1})	TSS (mg L^{-1})	Turbidity (NTU)	Depth (cm)	Water Tem (℃)
1	140	4.3	1490	6.8	8850	5630	216	54	105	29
2	55	5	1420	7.1	6680	4380	90	35	70	32
3	49	5.5	1430	7.0	7530	3950	104	38	56	33
4	60	5.75	1416	7.1	7644	4450	98	39	95	34
5	45	5.3	1390	7.5	6200	3850	90	35	60	32
6	48	5.6	1400	7.4	5950	3790	90	35	65	31
7	39	5.5	1430	7.0	6980	3720	104	38	52	34
8	32	5.9	1360	7.2	4725	3780	48	23	80	36
The total water storage of the marsh						(M^3)		18500000		
Outlet (UmAljury)						m^3/sec		2		
WTP (water treatment plant sewage)						m^3/sec		1		
(Galal Badra)						m^3/sec		00		
(Tursaq)						m^3/sec		00		

Biological oxygen demand (BOD)

After 5 days of incubation at 20 ℃, the BOD value was used to evaluate the water organic pollution in mg L^{-1}. It is clear that the concentrations of pollutants increased at point 1 to reach 180 mg L^{-1} and gradually decreased when moving away from point 1 in addition to the decrease in concentrations in the summer to reach 140 mg L^{-1}. Climate change and the loss of large quantities of water leads to the spread of the pollutant clearly to areas near point 1 (Fig. 3).

Dissolved oxygen (DO)

Dissolved oxygen is one of the most important factors used to assess water quality. Through the results of the tests, we noted that DO concentration was less than 5 mg L^{-1} to reach 4.3 mg L^{-1}, especially in the summer. According to Fig. 4, we noticed an elevation in DO values during the summer, in addition to a significant decrease in concentration at point 1.

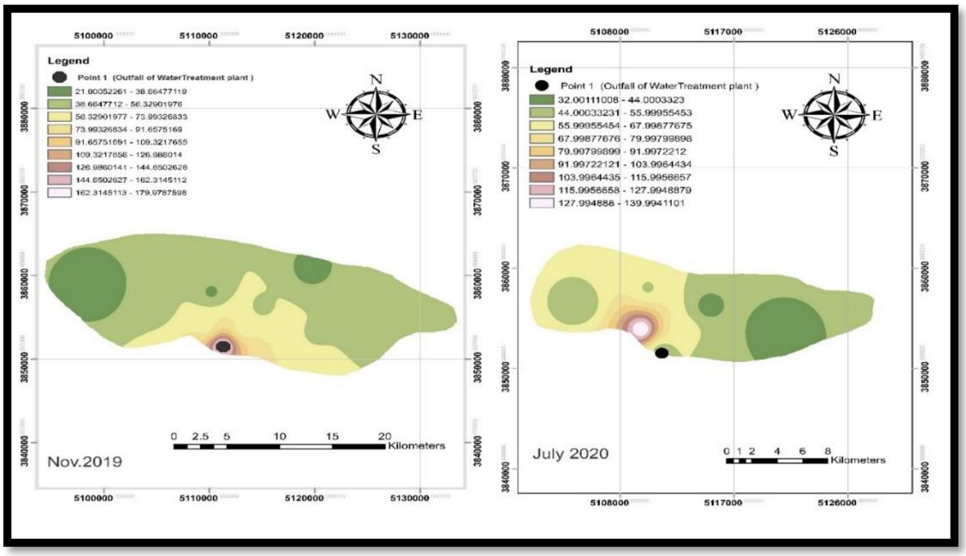

Fig. 3. Spatial variation of BOD in Al- Shuwaija Marsh.

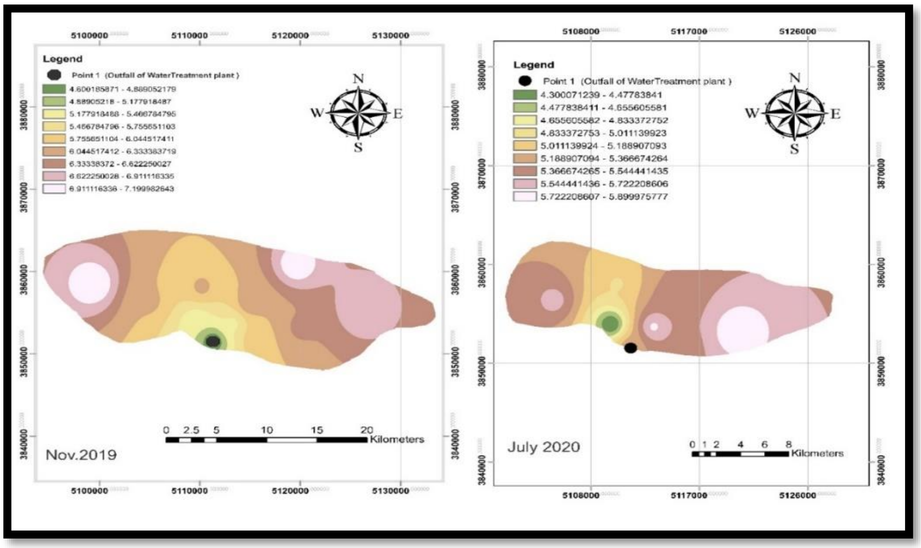

Fig. 4. Spatial variation of DO in Al- Shuwaija Marsh.

Electrical conductivity (EC)

It was noticed that EC values increased during the summer season to range between 6480 and 8850 µS cm-1, while in the rainy season, the value of EC decreased ranging between 2250 and 6480 µS cm-1 except for point 1 that remaind high as a result of its impact on sewage and the quality of the soil that was affected by accumulations of salt sediments (Fig. 5).

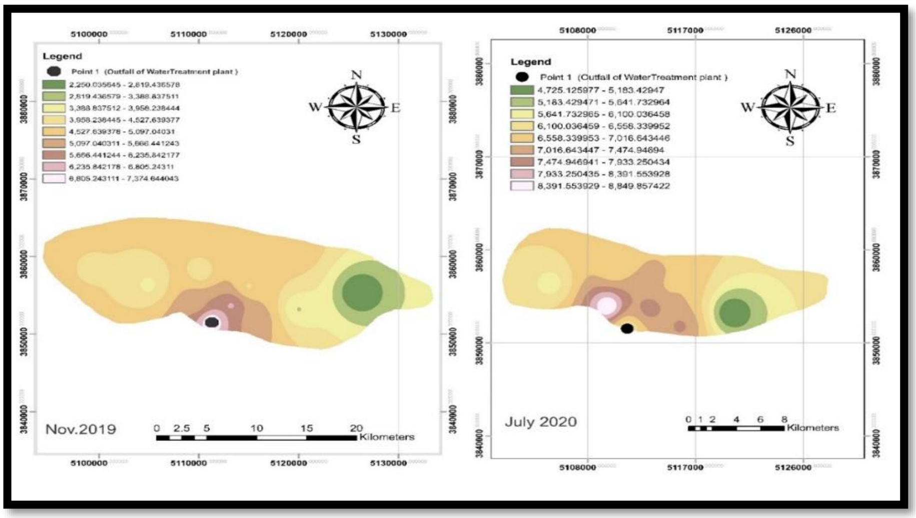

Fig. 5. Spatial variation of (EC) in Al- Shuwaija Marsh.

Total dissolved solids (TDS)

Fig. 6 shows the spatial distribution of TDS during November and July in the form of IDW maps of the study area. It was found that TDS in the water samples ranged from 1760 and 4682 mg L^{-1} during March and from 3950 to 5630 mg L^{-1} in July. The reason for the high level of dissolved solids in the marsh, especially for the areas beside Point 1, may be due to the sewage water of the treatment plant, in addition to the tributaries water and high sediments as a result of rainwater run-off.

Total suspended solids (TSS)

The values of TSS in water samples ranged from 24 to 100 mg L^{-1} in surface waters during March and from 98 to 216 mg L^{-1} in July. In this study, it was observed that those values are very high in surface waters. This can be attributed to the presence of poor soil through which tributaries (Galal Badra and Turkz River) pass. The IDW maps presented in Fig. 7 show the spatial distribution in the study area.

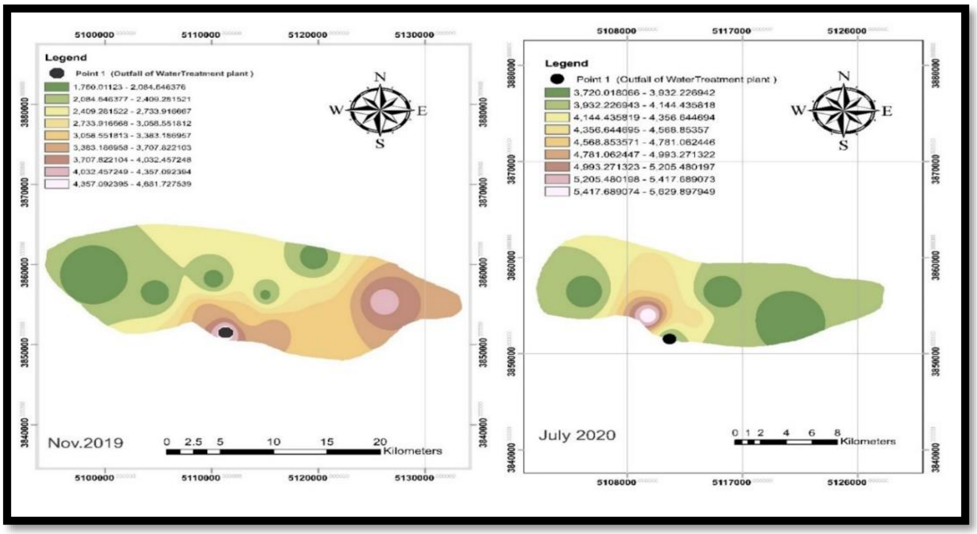

Fig. 6. Spatial variation of (TDS) in Al- Shuwaija Marsh.

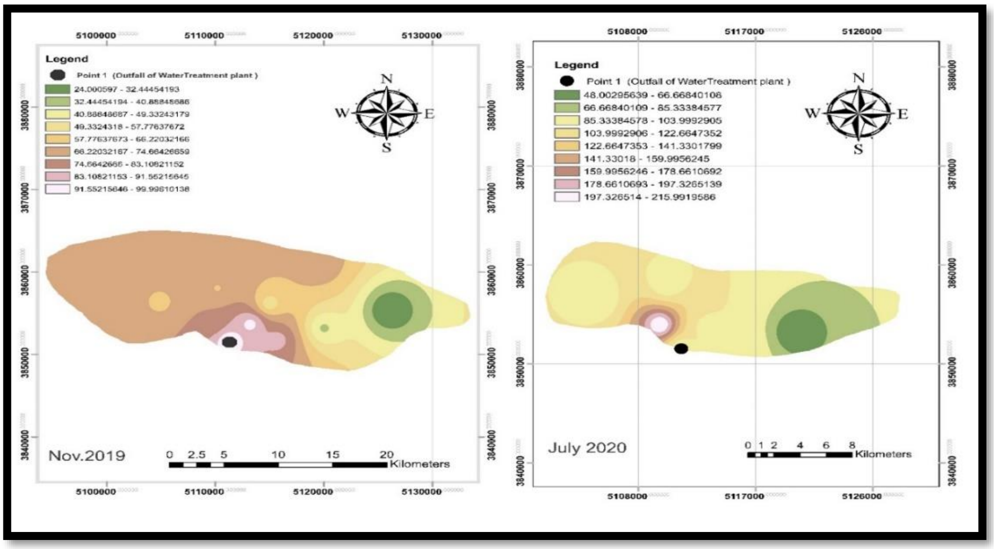

Fig. 7. Spatial variation of TSS in Al- Shuwaija Marsh.

Total hardness (TH)

The values analysis indicated that the total hardness of water samples ranged from 585 to 800 mg L^{-1} in surface waters in March, while from 1416 to 1490 mg L^{-1} in surface waters. The reason for this rise is the effect of wastewater in point 1. The IDW maps shown in Fig. 8 illustrate the spatial distribution of total alkalinity.

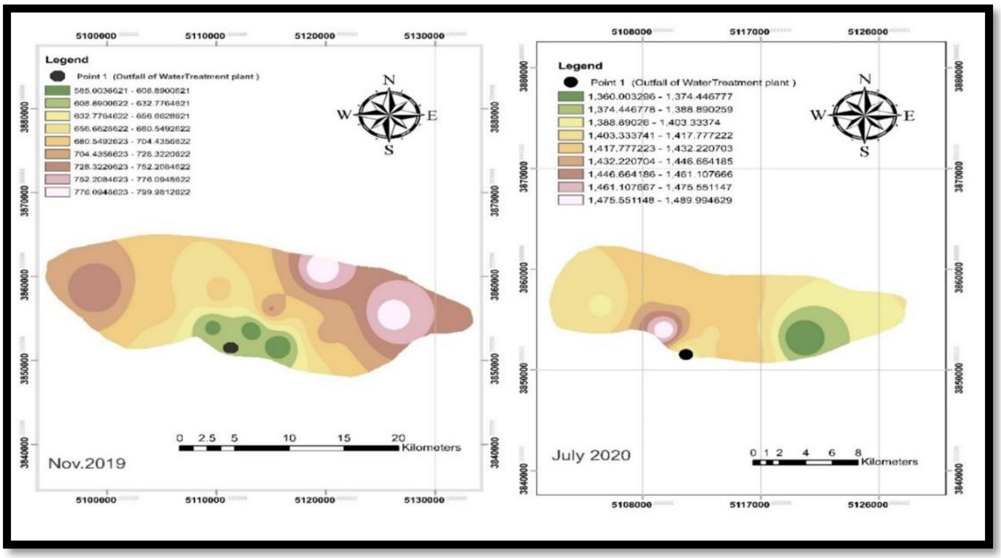

Fig. 8. Spatial variation of (T.H) in Al- Shuwaija Marsh.

Turbidity

It is clear that the values increased in July to reach 54 NTU, while dropped by 22% in the winter season to reach 42 NTU. The IDW maps shown in Fig. 9 illustrate the spatial distribution of total alkalinity.

Hydrogen ions (pH)

The pH level of the water in the study area in the summer ranged between 6.9 and 7.2 which was in the desirable range, i.e., 6.5 to 8.5. In the winter season, the scale ranged between 7.1 and 8.2, which is in the desirable range, i.e., 6.5 to 8.5. Fig. 10 depicts the spatial distribution of pH in the study in the region, a low pH concentration was observed at point 1.

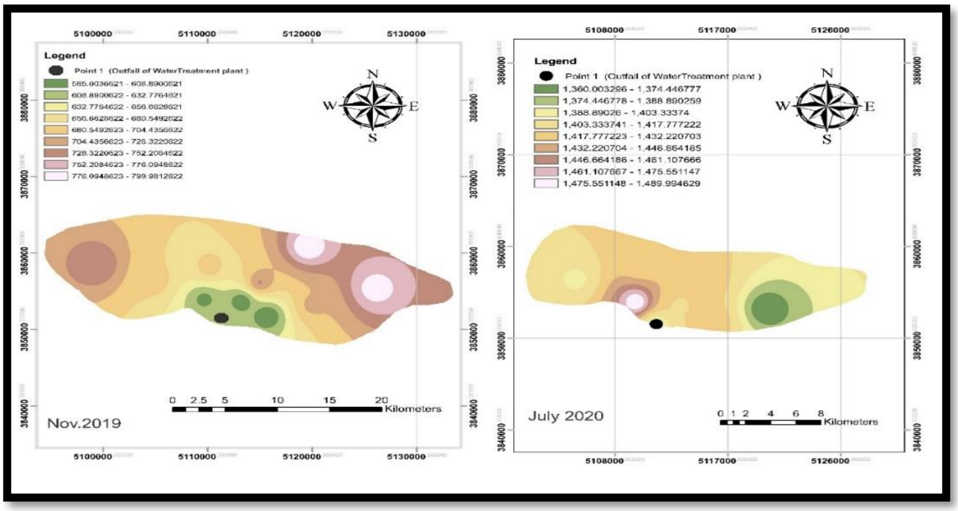

Fig. 9. Spatial variation of (T.H) in Al- Shuwaija Marsh.

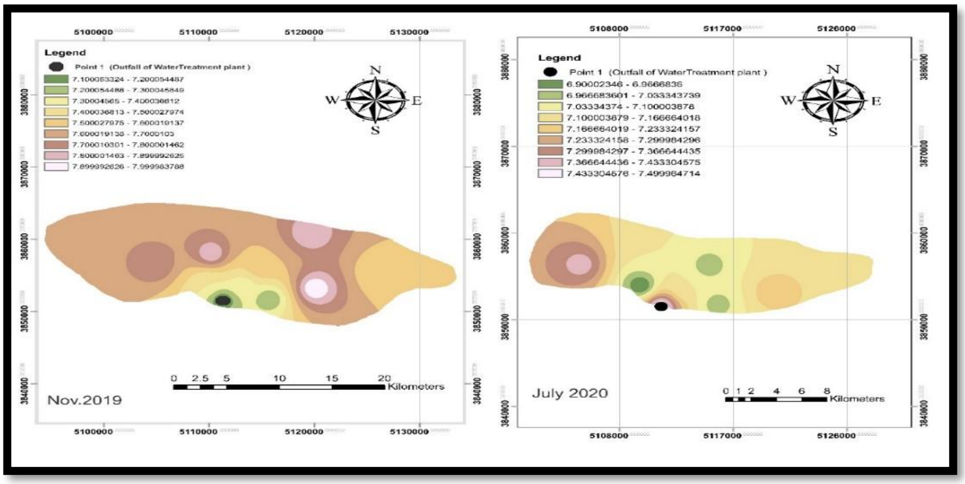

Fig. 10. Spatial variation of (pH) in Al- Shuwaija Marsh.

Depth of water

It is clear that the water level rises in the winter to reach 180 cm at one point, which is considered the water collection point as the lowest point, In addition, the area and depths of water recede in the summer, bringing the amount of water storage to 15,000,000 m^3. Fig. 11 indictes the spatial distribution of the depth of water in the study area.

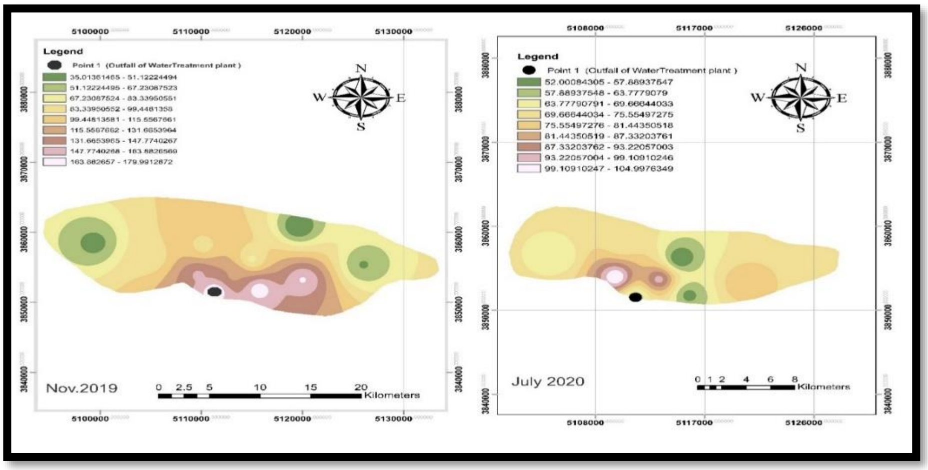

Fig. 11. Spatial variation of (Depth of water) in Al- Shuwaija Marsh.

CONCLUSIONS

The location at point 1 is considered the most polluted part of the study area as a result of dumping untreated sewage from the Kut sewage treatment plant which is discharged directly into it, in addition to its low level, which leads to water collection for both season. So it is necessary to Find appropriate solutions to evaluate the work of the sewage treatment plant through the development of the technological path and the addition of additional treatment units in order to improve the quality of treated water and according to the parameters of the Ministry of Environment as well as the water resources conservation system.

- The pollutants wee spread in the summer more widely in points 2, 3, 4 and 8 as a result of the drop in the quantities of inflow and low depths of water in the marsh.
- The water levels decreased significantly during July to reach 40 cm, in addition to the decline in the flooded area of the marsh to reach half its area in March as a result of several factors, the most important is the evaporation of large quantities of water as a result of high temperatures, shallow depths of water and the extended areas of the marsh.
- Discharge of large quantities of the stored marsh water into Tigris River through the Um-Aljury canal ranging from 0 to 50 $m^3 sec^{-1}$, which leads to the loss of large quantities of marsh water and the spread of pollutants. So, it is important to work in order to reduce the discharge of the Um-Aljury canal during the dry and receding season, which starts in July and ends in November, and will help to maintain the amount of water in the above reservoirs.
- The spatial distribution maps of water quality parameters may be useful in environmental monitoring of the water of the marsh.

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