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THE ENVIRONMENTAL STATUS OF TIGRIS RIVER WATER IN MOSUL CITY, NORTHERN OF IRAQ

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Abstract

The current study aims to assess the quality of the Tigris river water and its suitability for drinking and domestic uses. Water samples were collected from five sites along Tigris river in Mosul city during the autumn (five replicates from each location) for physical, chemical, and bacteriological tests based on international standard methods, with the use of NSFWQI Model to evaluate water quality using nine characteristics compared with the qualitative curves of (Qi). The results showed the water quality index (NSFWQI) values ranged from 61.1 to 65.3, which was a type of medium water quality (category C) as a source of drinking water and domestic uses. This relative deterioration of the river water quality in the city of Mosul is due to contamination with faecal coliform, resulting from the discharge of sewage and to hospitals effluents without any treatment through many estuaries spread on both sides of the river.

Key words : Tigris river, environmental status, water.

Introduction

The protection and management of water resources is one of the pillars of national security and important for any country in the world, especially the arid and semi-arid zones, whose water resources are from outside the borders, as is the case in Iraq, which adds a threat to the climate besides the threats of rain and scarcity of rains, and the water resources countries may try to control the waters originating in them and use them economically and politically to achieve strategic goals.

Studies indicate that there are insufficient water supplies within the year 2025, especially the main regions of the world, such as the Middle East, India and Pakistan, so, we must build a good economic and trade relations and political with upstream countries and manage and resolve politically outstanding problems, as well as Iraq's water resources management efficiently through scientific institutions, proper planning, combating the problems of pollution of water resources and rationalize water consumption (Al-Saffawi, 2018a). Tigris River is the main source of water for different purposes in Nineveh Governorate and many Iraqi cities, so it must be protected from pollution sources and impose penalties on the transgressors. Therefore, studies and investigations should continue with the use of modern methods of evaluation to determine the reality of water quality using water quality models WQI that spread after the suggestion of a mathematical model by Horton in 1965 which was then developed by Brown in 1970 (Kablan *et al.*, 2018). Over time, a large number of models were proposed and developed due to the ability of evidence to give a single value that reflects the interference between the large numbers of data and characteristics of water that are understood by everyone such as the logarithmic model, weighted arithmetic water quality Index, Canadian model CCMEWQI, Oregon Water Quality Index (OWQI) and National Sanitation Foundation Water Quality Index, NSFWQI (Poonam *et al.*, 2015; Gulgundi and Shetty, 2018; Dawood *et al.*, 2019; Talat *et al.*, 2019; Ramadhan *et al.*, 2018).

There are many studies conducted in this field including a study conducted by Al-Saffawi (2018b) study on the application of the Canadian model (CCME WQI) to evaluate the quality of water resources in the Al-

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Mahalabiyah district, west of Mosul, for drinking purposes, which indicated that 83% of the water samples studied were from the Marginal water class, and the rest were Poor quality for drinking. as well as the study of Al-Saffawi *et al.*, (2018) to assess the quality of water sources for the Gleewkhan village northeastern of Iraq for drinking and domestic uses using water quality models (WQI model) which indicated that the quality of water studied were inadequately unsuitable for drinking and domestic uses because of bacterial contamination. Finally, Talaat and Al-Saffawi (2018) studied the effect of discharged sewage water at Cara Saray disposition in the quality of Tigris river water in Mosul city, which indicated high organic load values, the total number of bacteria and faecal coliform bacteria. Therefore, the current study came to evaluate the water of the Tigris River within the city of Mosul and its suitability as a source of drinking water and civil purposes using the NSFWQI index.

Materials and Methods

Five sites were identified on the Tigris River within the city of Mosul to collect samples away from the sites of wastewater disposal during the autumn (five replications) for the year 2018 and shown in (Table 1 & Fig. 1).

Table 1: Coordinates of the studied sites of Tigris river at Mosul city.

S.No.	Sites	E	N
1	Mushairefah	43°04’17"	36°23’39"
2	Forest area	43°40’02"	36°22’02"
3	Fifth bridge	43°07’43"	36°21’19"
4	Al-Hryia bridge	43°08’41"	36°20’28"
5	Al-Busaif village	43°10’25"	36°18’10"

Standard methods were followed for collecting and analyzing samples in the Environmental Lab. of the Dept of Biology, College of Education, University of Mosul, as pH, Dissolved salts TDS, Dissolved oxygen Do and organic load BOD5 were identified, as well as determining the concentrations of Total hardness T.H, Total Alkalinity TA, Sulfates SO_4, Nitrates NO_3, Total number of bacteria TPC and Faecal coliform FC (APHA, 1998, 2017).

Calculation of the water quality index

Water quality had been categorized by Horton in 1965 and then in 1970 Brown et al. and developing a common water quality index (WQI) (Kablan *et al.*, 2018). For the

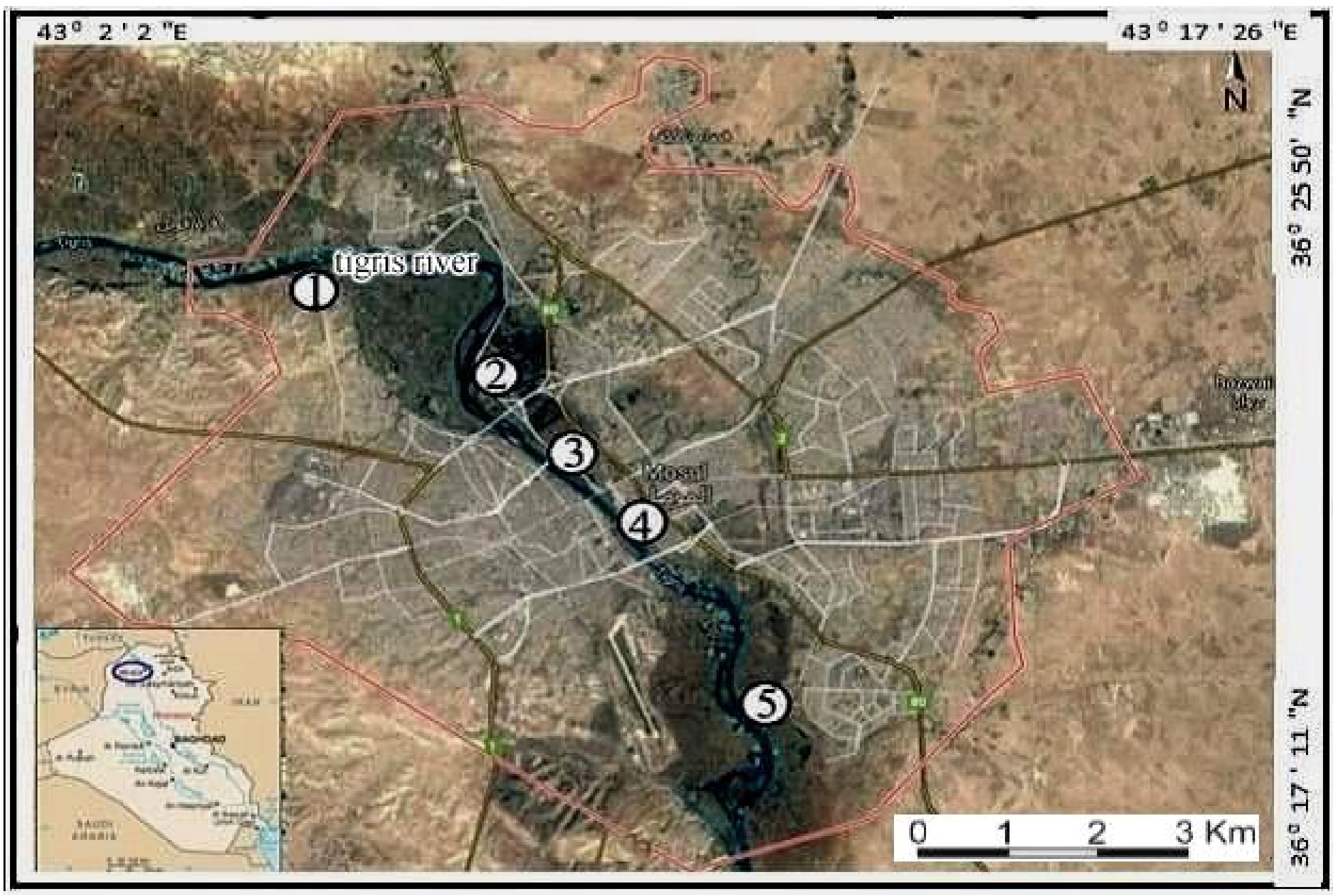

Fig. 1: Sample collection sites from Tigris river in Mosul city.

calculation of National sanitation foundation water quality index (NSFWQI), the raw analytical results for the water quality parameters are converted into sub-index values (Qi), which can be done by transforming each parameter into 0 to 100 scales by using subindex curves (Mirzaeia *et al.*, 2016; Srivastava and Kumar, 2013). This index is, which depend on the weight (Wi) as shown in table 2 and subindices (Qi) of each parameter for the nine major criteria to determining the quality of water that is, Temperature, pH, DO, BOD, TDS, Nitrates, F. coliform bacteria, T. Hardness and Sulfate, which is determined using equations as indicated (Soumaila *et al.*, 2019):

$$NSFWQI = \Sigma\ Qi \times Wi$$

Where, Qi: ith sub-index of the ith parameter; Wi: ith weight of an ith parameter.

Then water quality index values (NSFWQI)are classified into five categories as shown in table 3.

Results and Discussion

1. Physical properties

The water temperature has an important role in influencing the reactions that occur in the water and the melting of salts from the sediments, as well as the activity of microorganisms in the processes of oxidation and reduction (Falowo *et al.*, 2017)

The results are shown in table 4 indicate that the water temperature of the Tigris River during the study period ranged between (22.6 to 26.0) °C, which is greatly affected by the climatic factors of the study area (Ramadhan *et al.*, 2018). As for total dissolved solids, the results indicate that the average values ranged between (246-388) mg.l^{-1}, these differences are due to the nature of wastewater dumped into the river, as well as the nature of the reactions that take place in the river water. The samples studied are within the permissible global limits for drinking (WHO, 2004).

2. Chemical properties

PH is an important criterion for assessing the suitability of water for drinking and various uses and the possibility of contamination, The results shown in Table 4.

Indicate that the values ranged between (7.5-8.2) and note the lack of fluctuation in the values for all studied sites, as the difference did not exceed 0.86 units as noted from table 1 that the difference between the rates for the studied sites did not exceed 0.42 units and this due to high buffering capacity of river water as a result of the presence of HCO_3^- ions, were it not for this capacity, the variations would have been significant and thus affect aquatic life (Kevat *et al.*, 2016), as lower values would increase the solubility of toxic metallic elements from the river's sediments such as aluminium and thus increase negative impacts on living organisms (Al-Saffawi *et al.*, 2018; Al-Saffawi, 2018b). As for the relative rise towards the alkalinity, it is caused by wastewater discharged to the river during its passage in Mosul city, which is saturated with residues of detergents with alkaline effect, as well as the activity of algae, aquatic plants and increased photosynthesis, which leads to the formation of alkalinity causes as shown in the equation (Manhan, 2004):

$$HCO_{-3} + H_2O \rightarrow \{CH_2O\} + O_2 + OH^-$$

As for dissolved oxygen and organic pregnancy values, it is considered one of the most important factors that affect water quality, and the large deficiency of dissolved oxygen has a harmful effect on aquatic organisms (Al-Asaaf Al-Saffawi, 2018).

The results are shown in table 1 indicate that the dissolved oxygen concentration in the river water ranged between (6.2-8.8) mg.l^{-1}, and the relative decrease in oxygen concentration may be due to the high organic load BOD5 when the river passed through Mosul city, which amounted to (6.40) mg.l^{-1} and the highest values at the sites 2 and 3 as a result of the discharge of sewage into the river, but the continuation of this discharge will increase the negative effects on the river and the occurrence of anoxic degradation of organic materials and the emission of unpleasant and disturbing odors (Al-Saffawi and Talaat, 2018; Al-Saffawi, 2019).

As for the total alkalinity, it rises with the passage of the river in the city to reach 216 mg.l^{-1} at site 3 as a result

Table 2: Weigh (Wi) factors of water quality properties.

Parameters	Temp.	pH	DO	BOD	NO_3	TDS	T.H	SO_4	F.C
Wi factor	0.10	0.12	0.17	0.11	0.10	0.08	0.07	0.10	0.15

Table 3: Standard water classification according to NSFWQI. (Paraster *et al.*, 2015).

NSFWQI	0.0 - 25	26 - 50	51 - 70	71 - 90	91 - 100
Status	Very Bad	Bad	Mudium	Good	Excellent
Category	E	D	C	B	A

Table 4: Range, mean and standard deviation of Tigris river water analysis results. mg.l^{-1}.

Sites		T.°C	pH	TDS	DO	BOD	T.H	T.A	SO_4	NO_3	TPC	F.C
1	Min.	25.7	6.90	2.59	7.00	0.11	156	76.0	35	0.11	150	260
	Max.	26.3	7.65	384	7.90	3.20	228	172	130	3.19	1100	438
	mean	26.0	7.41	300	7.51	1.14	180	131	77.1	1.23	570	325
	±Sd	0.23	0.29	45	0.39	1.07	24.9	25.0	34.0	1.10	396	80
2	Min.	23.6	6.79	282	7.10	0.53	180	401	48	0.78	43	590
	Max.	24.4	7.65	522	7.90	6.40	220	180	228	2.92	1100	650
	mean	24.0	7.41	388	7.64	1.92	190	135	124	1.44	584	623
	±Sd	0.28	0.29	90	0.33	2.25	15.9	41.0	66.3	0.81	516	25
3	Min.	24.6	6.49	224	6.90	0.70	176	116	75.5	0.64	43	584
	Max.	25.2	7.30	288	7.95	6.40	244	216	248	1.94	1100	736
	mean	25.0	6.99	246	7.59	1.92	222	146	155	1.14	412	660
	±Sd	0.25	0.30	34.9	0.41	2.24	25.1	38.4	65.6	0.47	487	62
4	Min.	22.6	6.84	288	6.89	0.61	176	88.0	63.7	1.07	43	368
	Max.	23.3	7.64	400	7.80	4.80	252	188	175	1.99	1100	780
	mean	23.0	7.38	332	7.34	1.53	199	129	119	1.45	438	553
	±Sd	0.26	0.31	38	0.44	1.63	26.9	36.5	49.2	0.31	412	171
5	Min.	24.5	6.68	272	6.70	0.17	172	120	68.1	0.13	210	356
	Max.	25.5	7.74	362	7.60	4.80	220	200	188	3.23	1100	564
	mean	25.0	7.31	303	7.33	1.44	197	153	133	1.65	922	448
	±Sd	0.37	0.39	31	0.36	1.700	16.4	30.5	46.6	1.11	356	87

TPC: Total bacteria cell $\times 10^3$ ml^{-1}., F.C: Faecal coliform cell$\times 10^2$ 100ml^{-1}.

of the discharge of sewage into the river rich in salts and organic materials, and thus the occurrence of biodegradation processes and the release of dissolved ions and CO_2 gas that dissolves in water forming a carbonic acid that interacts with $CaCO_3$ found in suspended matter and bottom sediments to form dissolved calcium bicarbonate, thereby increasing water alkalinity (Manhan, 2004).

As for total hardness, the calcium and magnesium ions are among the most common ions causing hardness in natural waters (Al-Saffawi, and Al-Sanjari, 2018), as their concentration reached to (244) mg.l^{-1} at site 3 and this is due to the discharge of residential sewage water to the river without any treatment for it. As well as for the sulfate and nitrate ions as increasing their concentrations during the passage of the river Mosul city, to reach the highest mean (155 to 1.65) mg.l^{-1} consecutively.

3. Bacterial properties

The most important problems of the water surface in Iraq and developing countries are microbial contamination and notes from table 4 high total number of bacteria and faecal coliform numbers for up to (1100×103 cell. ml^{-1}, 780×102cell. 100 ml^{-1}) respectively. This means the presence of faecal contamination and the possibility of the presence of most pathogens such as cholera, Shigella, typhoid, Salmonella, Poliomyelitis and viral hepatitis etc (Al-Saffawi, 2007c). This large increase in the number of bacteria is a result of the state of carelessness and illegal transgression by throwing sewage into the river. Rather, the matter reached the disposal of septic tank wastes, and this will lead to the deterioration of the river's water, damage to water wealth and national water security.

4. Assessment of Tigris river water quality

Results of the National Sanitation Foundation Water Quality Index (NSFWQI) values and the product of multiplied sub-index values with weight as shown in table 5) that NSFWQI values ranged from (51.5 to 65.3) This means that the water quality of all samples studied is of medium quality type (category C).

In general, the reality of Tigris river water is relatively deteriorating due to the exposure to sewage discharge and the dumping of livestock waste from villages on its sides since the river entered Iraqi territory until it reached the Mosul city. However, the deterioration of the river's water notes after entering the city, to go the value of NSFWQI down to 51.5 at site 4 (Mosul city centre) This deterioration in the quality of water is due mainly to the contamination of fecal coliform bacteria and then followed by the temperature and TDS were reached the Qi ×Wi) values to 0.60,1.6 and 3.64 consecutively.

Table 5: Results values of (Qi×Wi), NSFWQI and water quality status of Tigris river in Mosul city.

Param / Sites	Qi×Wi									NSFWQI	
	T°c	pH	TDS	DO	BOD	NO_3	F.C	T.H	SO_4	Value	Status
1	1.6	11.0	4.64	16.2	9.9	9.2	1.05	5.11	6.6	65.3	Medium
2	1.8	11.0	3.64	15.8	8.8	8.8	0.75	5.40	5.0	61.0	Medium
3	1.7	10.4	5.28	15.6	9.0	9.4	0.60	4.83	4.8	61.6	Medium
4	1.8	10.9	4.32	15.6	9.2	8.8	0.75	4.90	5.2	51.5	Medium
5	1.8	10.8	4.64	15.5	9.5	8.6	0.45	4.97	4.8	61.1	Medium

The study concludes that the deterioration of water quality is mainly due to the inputs of municipal activities and agricultural wastes into the river. The highest effective values of (Qi×Wi) belongs to F. coliform, Temperature and Total dissolved solids TDS consecutively and these parameters are the most effective in the NSFWQI calculations. Therefore, we recommend using WQI as an effective tool to classify river water as Tigris for different uses and gives an accurate idea of the pollution load in a river and the degree of suitability of water as a source of drinking water and other uses, as well as periodic checks of river water to stand in the event of any emergency.

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