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Impacts of untreated sewage effluent on Tigris river water quality using (NSF-WQI) index

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Abstract

The Tigris River (T.R) considers as life vein of Iraq, in spite of thousands of cubic meters of untreated sewage discharged daily. Many studies indicate deterioration in T.R water quality using different environmental assessment tool, National Sanitation Foundation Water Quality Index (NFS-WQI) is one of the good mathematical model that has been used to assess the potential impact of untreated sewage discharge on T.R water quality. Four selected sampling station on the T.R main stream within Baghdad city during (Feb.2019-Feb.2020) visited six times. Nine water quality parameters " Biochemical oxygen demand (BOD_5), Electrical conductivity (E.C), Dissolved oxygen (DO), Nitrates (NO_3), Total Phosphates (PO_4), Turbidity (Tur.), Total Solids (TS), pH, Fecal Coliform (FC) " were participated to calculate the (NFS-WQI) index value, our resulted (NSF_WQI) values show that the T.R water quality affected by discharging untreated sewage, were the index values decrease from (medium) at station.1 (control station) to (Bad) at station.2 (discharge point); but the situation get better in the last station recording (medium). Most of the discharge sewage was "domestic" rich with organic matters leading to decreasing dissolved oxygen level "under the minimum permissible level" reaching (2.23 and 4.30 mg/l) in station 2, while its concentration were (8.57 and 5.60 mg/l) consider " healthy" in station (1) during the wet and dry season respectively. Fecal coliforms and B.O.D $_5$ were increase in Station (2); but after a distance of about 500 meters, the T.R start to mitigate the impacts, to recover after one kilometer far from station (2). This may due to the dilution by the passing water mass through T.R. The discharging of untreated sewage to the rivers may pose significant health risks; our study recommends the necessity of stopping these illegal acts with impose of hard punishment to protect Tigris River.

Keyword: Water quality, Sewage, Tigris River, NFS-WQI.

Introduction

The SDG's 6th goal focuses on the ensuring of adequate "sustainable" management of water and sanitation. That may reveal that sewage issue located in the core of international effort to tackle climate change impacts (Eurepean Union, 2020). Recently, 59 per cent of domestic wastewater "over world" flow is collected and safely treated, but 41 % of sewage was untreated and poses risks to the environment and public health (World Health Organization, 2018). The recent international published studies of sewage content analysis show the presence of hazard material like trace of medical drugs (Fatima et al., 2015), amount of fate, pharmaceuticals, personal care products and endocrine disrupting chemicals (Lokesh et al., 2013), which may have impacts to human health directly or in directly.

The T.R consider as the life vein of Iraq; where the most Iraqi cities getting their water supply for different purposes. The official published data of Iraqi sewage services mention that the rate of Iraqi cities served by sewage collecting system was (34.6%) in 2017; with percentages reach of (42.5 and 39.9 %) during 2015 and 2016 respectively (Central Statistical Organisation, 2017). The (T.R) water quality affected by discharge millions cubic meters of untreated sewage monthly (Kadhem, 2013). As T.R is very important "fresh water" river in Iraq; many studies has been done to monitoring its quality , the resulted score never reached "Excellent" nor down to "Unsuitable" class (Alobaidy et al., 2010), while the water quality of Al-Gharraf river "one of T.R

branches" was assess using water quality index (NFS WQI); selected 13 "physical, chemical, and biological" variables measured monthly at ten stations during 2015; resulted NSF-WQI range were (1–70) indicating a medium quality [8], The recent study of (Al-Sudani, 2020) analyzed the water quality data from 10-sampling site along T.R within Baghdad city during (2011-2018); using Overall Index of Pollution (OIP), showing that T.R water quality was unacceptable class.

Our study aimed to assess the impacts of discharging untreated sewage to the T.R with in Baghdad city.

Materials and Methods

1.Sampling stations: Four sampling station were selected (Al-Ae'ma Bridge, Al-Kadhimy sewage pumping station, Al Whada drinking water and Al-Karama drinking water treatment plant) on the T.R main stream within Baghdad city (Figure.1). Sampling was conducted six times in wet and dry seasons from May-2019 to May-2020; sampling time were (10.30 am to 2.30 pm) during the first week of respective month. Using Global Positioning System (model Garmin e-Trex 22X) each sampling was surveyed accordingly.

2.Water samples collection and analysis: Nine water quality parameters "physical, chemical, and microbiological" were patriciate to calculate the water quality index according to (NSF-WQI). The selected parameters are: Biochemical Oxygen Demand (BOD), Conductivity (E.C), Dissolved Oxygen (DO), Nitrates (NO3), Total Phosphates (PO4), Turbidity (Tur.), Total Solids (TS), pH, Fecal Coliform (F.C), they were analyzed according to standard methods and procedures as presented in table 1. (APHA, 2012).

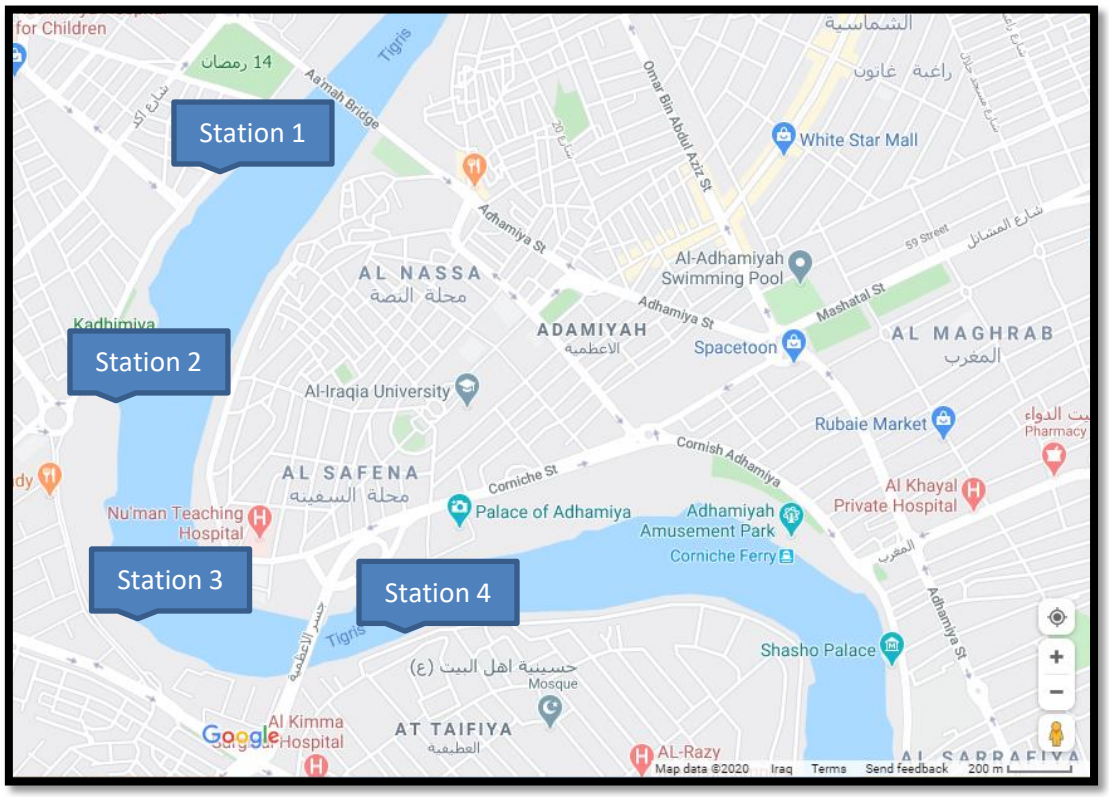

Figure1. Sampling station on T.R within Baghdad city

Table 1. Measurement methods of the water quality parameters

Parameters	Unit	Method
BOD_5	mg/l	Winkler method (APHA,2012)
EC	µS/cm	Conductivity Meter WTW 720
DO	mg/l	Winkler method
Nitrate (NO_3)	mg/l	UV-Vis Spectrophotometer Shimadzu 1800
Total Phosphate (PO_4)	mg/l	UV-Vis Spectrophotometer Shimadzu 1800
Turbidity (Tur.)	NTU	Turbidity meter Lenovo
TS	mg/l	
pH	-	pH meter WTW 7110
Fecal coliform (F.C)	Cell/100 ml	Most probable number

3.Application of (NSF-WQI): National Sanitation Foundation water quality Index calculated by nine selected parameters such as: BOD, E.C, DO, NO3, PO4, Tur., TS, pH, and FC, the index calculator is available online: http://www.water-research.net/index.php/water-treatment/water-monitoring/monitoring-the-quality-of-surfacewaters.

NSF-WQI index expresses general water quality and does not serve particular water usage. Some of the index variables have special importance, so a weighted mean is good tool to estimate the index, table 2. Show the different parameters weight (Brown et al., 1970).

Table 2. Weight scores of the nine NSF-WQI parameters

Parameters	Weighted mean
DO	0.17
E.C	0.1
F.C	0.16
pH	0.10
BOD	0.12
NO_3	0.1
PO_4	0.1
Tur.	0.08
TS	0.07

The weighted score (Wi) must be multiplied by the resulting sub-index value (Li) of the parameter obtained by the NSFWQI, then it will be summed by the equation: NSF-WQI= $\sum$Wi x Li

Where NSF-WQI is the score of the water quality index; Wi is the weighted score; and Li is the sub-index value (all calculated by the index calculator available online).

The resulting NSF-WQI score classified to five class: (91-100 = Excellent); (71-90 = Good); (51-70 = Medium); (26-50 = Bad) and (0-25 = Very bad) according to (Abbasi, 2012).

Results and Discussion

1.Physio-chemical and bacteriological parameters: Seasonal value of physical, chemical and bacteriological analysis in the four study stations "wet and dry season" has been comparing with Iraqi standard for drinking water of Iraq (IQS, 2009), and world health organization drinking water standard (World Health Organization, 2017) (Table 3).

The resulted data of water quality analysis of T.R (Dry and wet season) showing that the station 2 (discharging point) was the most impacted comparing with station 1 (control) and the rest station (Table 4).

Table 3. The mean value of water quality parameters

Parameter	St.1	St.2	St.3	St.4	Drinking-Water Standard IQS: 417	WHO guideline value
$B.O.D_5$	2.6	3.9	3.7	2.5	-	5≤
E.C	795.6	1091.7	760.5	782.5	1000	1500
DO	7.1	3.3	5.8	5.9	-	-
NO_3	4.5	4.4	3.6	4.8	50	50
PO_4	0.5	0.9	0.4	0.4	0.27	0.27
Tur.	24.8	146.6	37.2	36.4	5	≤5
TS	159.7	148.7	52.2	51.5	-	-
pH	7.7	7.7	7.8	7.8	7 - 8.5	6.5 - 9
F.C	4183.3	13000.0	2003.3	5440.3	200	200

Table 4. The physio-chemical parameters of Tigris River water quality

	Parameters	Wet.	Dry	Mean	Std. Deviation	Parameters	Wet.	Dry	Mean	Std. Deviation
Station.1	$B.O.D_5$	1.4	3.8	2.6	1.2	Station.3 $B.O.D_5$	3.0	4.5		0.8
	E.C	748.6	842.7	795.7	47.0	E.C	744.0	777.0	760.5	16.5
	D.O	8.6	5.6	7.1	1.5	D.O	6.0	5.7		0.1
	No_3	6.0	3.0	4.5	1.5	No_3	5.2	1.9	3.6	1.7
	Po_4	0.7	0.3	0.5	0.2	Po_4	0.7	0.1	0.4	0.3
	Tur.	14.4	35.3	24.9	10.5	Tur.	43.4	31.0	37.2	6.2
	TS	56.7	262.7	159.7	103.0	TS	44.3	60.0	52.2	7.8
	pH	7.8	7.6	7.7	0.1	pH	7.8	7.8	7.8	0.0
	F.C	256.7	8110.0	4183.4	3926.7	F.C	2340.0	1666.7		336.7
Station.2	$B.O.D_5$	2.5	5.4	9	1.5	Station.4 $B.O.D_5$	2.0	3.1		0.5
	E.C	1165.0	1018.3	1091.7	73.3	E.C	794.3	770.7	782.5	11.8
	D.O	2.2	4.3	3.3	1.0	D.O	6.0	5.8	5.9	0.1
	NO_3	5.9	3.0		1.5	NO_3	6.6	2.9	4.8	1.8
	PO_4	1.2	0.7		0.3	PO_4	0.7	0.1	0.4	0.3
	Tur.	193.7	99.5	146.6	47.1	Tur.	44.2	28.6	36.4	7.8
	TS	229.3	68.0	148.7	80.7	TS	67.3	35.7	51.5	15.8
	pH	7.7	7.6	7.7	0.0	pH	7.8	7.8	7.8	0.0
	F.C	6666.7	19333.3	13000.0	6333.3	F.C	3034.0	7846.7	5440.3	2406.3

The $B.O.D_5$-value considers as indicator of the quantity of dissolved oxygen usage by micro-organism to metabolite the organic matter in water column during 5 days in dark (Naubi et al., 2016). Our results indicated that station.2 recorded the highest $B.O.D_5$-value (5.4 mg/l) during the dry season, while the lowest was (1.4 mg/l) during the wet season in station 1.

Dissolved oxygen is essential for respiration, the oxygen concentration may play control role to biota distribution (Al-Shujairi, 2013). The D.O-values in our study range from (8.6 mg/l) in station.1 during the wet season to (2.2 mg/l) in station.2 during the dry season; in healthy water oxygen level must don't go down (5mg/l) (Abbasi, 2012). In light of the result of station.2 is impacted site due to decreasing the D.O level under the permissible level during the study period; that may due to the discharging of untreated sewage direct in this point. Same result recoded in the study of (Al-Sudani, 2020) mention that the B.O.D5 and D.O level "in some point" in T.R go out the acceptable scale of healthy water criteria; that may participate in rising the OIP score.

Fecal coliform Bactria indicate directly that water sample contaminated with domestic untreated sewage, the range of F.C (cell/100ml) were varied from (19333.3 cell/100ml) in station 2 in the dry season, to (256.7 cell/100ml) in station 1 in the dry season.

Plotted the mean values of B.O.D5 and F.C in hand, and D.O in other hand indicate the presence of organic matter in water column, our result indicating clearly the impacts of sewage discharging on the water quality of T.R in station 2 (Figure.2).

All anion (NO_3, PO_4) concentration was within healthy water range (Table.3), same result obtains by (Kadhem, 2013). Salinity is estimated by measuring the water ability to conduct electricity. Water salt contain may expressed in electrical conductivity (E.C), The E.C-value of our study varied from (748 µs/cm) in station 1 during wet season to (1018.3 µs/cm) during dry season in station 2. While the E.C –values were lowest (293-346 µs/cm) in the source of T.R (Nihal et al., 2019). Turbidity refers to water transparency, it is expressing the amount of suspended solids in the water column, consequently the turbidity values were high in all stations during the study periods, it were range from a minimum of (14.4 NTU) in station.1 to a maxi-mum of (193 NTU) in station 2 during wet season. The T.S indicated the presences of particulate "non-dissolved" matter in water column it is consider as undesirable feature causing more turbidity, our study indicated that T.S level in T.R up over the acceptable range of healthy water, it were range from (31mg/l) in station 3 (dry season) to (229 mg/l) in station 2 (wet season). Increasing level of turbidity and T.S in T.R documented by (Kadhem, 2013). The pH is a scale used to estimate the acidity or alkalinity of water. Most aquatic biota have a selective pH range around 6–8 units, our study proofed that Iraqi water pH-value look little bit stable and tend to be up of 7, our study range was (7.6-7.8) in all study station, this may due to the natural existence of the carbonates and bicarbonates (Naubi et al., 2016).

2. Using (NSF-WQI): Using water quality index becomes an active tool in water management programs in many countries. One of The successful models is (NSF-WQI) index developed by (Brown et al., 1970). Brown's index represents general water quality. It does not incorporate specific water usage such as drinking water supply, agriculture, industry, etc. due to this difficulty has been an clear tendency for some researcher to be heavily influenced in their judgments of parameter suitability for inclusion in a WQI calculation (Abbasi, 2012). Plotted our result showing clear impact of sewage discharging on water quality of T.R within Baghdad city, the (NSF-WQI) value recorded (42-40) score in station 2 (the discharge point); presented bad water quality, while the water quality in station 1 (control) was acceptable, with value range (59-52) (Figure.3).

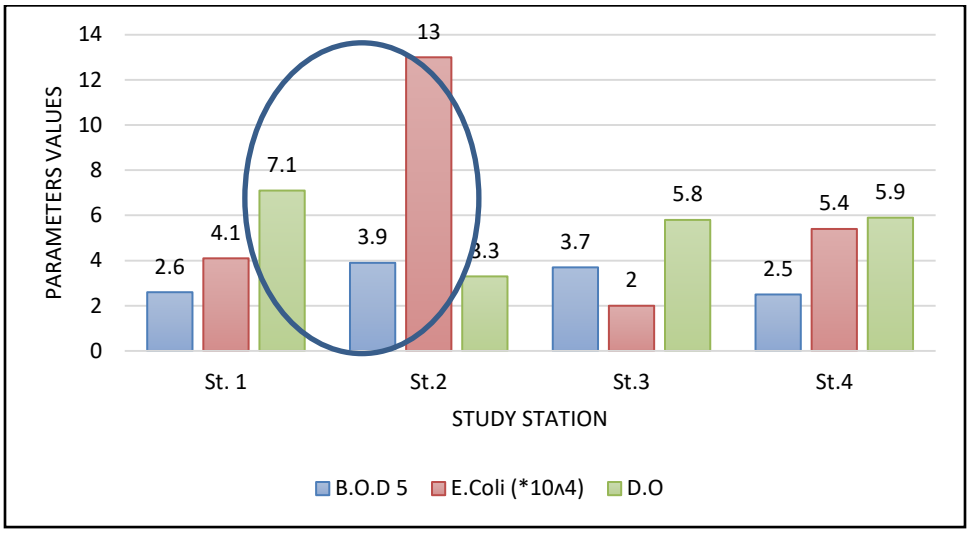

Figure 2. Temporal change in selected water quality parameters mean value

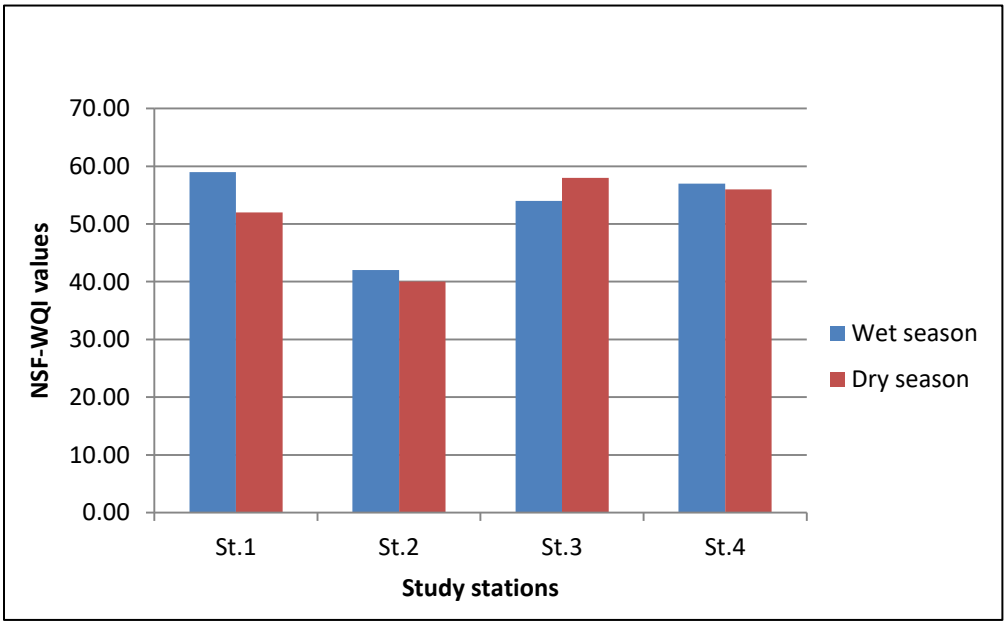

Figure 3.Seasonal variation in NSF-WQI values of the Tigris River

Conclusions

1- Urgent alarm must rings to stop discharging untreated “partially" sewage to Tigris River.
2- Many hazardous and pathogens interring the river via sewage and play real health risk.
3- Efforts are needed from all the concerned authorities for rehabilitation the sewage services.
4- The right of Iraq population is required in keeping their environment clean.
5- Developing an Iraqi water quality index (family for multi-use) is needed.

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