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Research Article

Turbidity and Total Suspended Solids as Physical Parameters for the Evaluating the Water Quality of Tigris River in Mosul City

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Abstract

In this investigation we sought to find whether the Tigris River was suitable for drinking water or not according to WHO guidelines. Tigris River is one of the most important surface water resources in Mosul city. During our research eight locations from Tigris River in Mosul city was chosen in the study period of five months (April, May, July, October, and December 2021) we focused on some of the physical parameters especially turbidity and total suspended solids beside the electrical conductivity, pH, and water temperature parameters. . Turbidity is used for measuring the clarity of the water, where it describes the amount of light blocked or scattered by floating particles in the water. The particles that cause the turbidity can harbor bacteria and viruses, so the turbidity can be a shield protecting the pathogens which hinder the disinfection process of the water either by chlorination or ultraviolet. The resent study concluded that a relationship ($r= 0.53$, $p= <0.05$) was established between turbidity and total suspended solids. The turbidity and TSS results were beyond the guidelines of WHO, whereas the high turbidity was due to the organic loads from the drainage of non-treated sewage which came from the both left and right coast. The classical raw water treatment plants in Mosul city could not treat the water and restore it to be within the international recommended levels of water supply.

Keywords: Water quality, Turbidity, TSS, WHO guidelines, River.

1. Introduction

The Tigris River represents one of the main sources of water as well as Euphrates in Iraq, Where the Tigris River originated from Turkey which feeds 80% of the water river, then it runs inside Syria before entering Iraq [1]. The quality of water in the Tigris Rivers of Iraq could be affected by external and internal influences, controlled and uncontrolled factors which affect negatively the quality of water [2]. The uncontrolled factors that are represented by the consequences of climate change resulted in a reduction in precipitation and temperature increase, as for the controlled factors such as Dams, irrigation, waste discharge, and industrial activities have a significantly negative influence on water resources, but their effects involve more specific regions [2,4].

Many dams built in the upper parts of the Tigris River in Turkey and Syria has a significant effect on the discharge of the river in Iraq, discharge significantly affect total suspended solids, since the turbidity is highly associated with total suspended solids (TSS) and thus the turbidity of the water will highly be affected by the discharge [3,5].

Turbidity represents water transparency of water and it is influenced mainly by color, temperature, and presence of suspended solid particulates and is considered an overall indicator of water quality [8]. Many factors could affect aqueous turbidity including sediments from erosion, bacteria, resuspension from the riverbed, waste discharge, algae growth, urban runoff, and many other possible problems [6,7].

In the current investigation, the main aim of this study was to describe the changes of turbidity and total suspended solids (TSS) and the relation between them in the 8 samplings sits, and their seasonal variation. Furthermore, to determine how is the water quality changed from the inlet of the river in Mosul until it leaves the city according to the turbidity and TSS by using an interpolation map. An attempt is made to evaluate the water quality of the Tigris River in Mosul city according to the turbidity and TSS because of its significance as the primary drinking water source for the city.

2. Materials and methods

2.1 The area of the study

Mosul city located in the north part of Iraq and it is the second-largest city after Baghdad. Tigris River is the main source of water for the city, but it is exposed to multiple sources of pollution since its entry into the city that have a direct impact on water quality and suitability.

2.2 Methodology

Samples were collected in 1 liter polyethylene (HDPE) bottles from the surface of the river, which had been carefully rinsed and washed in advance, where the bottles first rinsed with river water before being filled. Water was collected from 8 locations (Table. 1, fig. 1) distributed along the river from the inlet of the river to Mosul city util the river leaves the city. samples were collected at the same point at five months in 2021 (15 April, 16 May, 12 July, 18 October, and 20 December) which covers four seasons.

Turbidity was analyzed by using (Hach 2010) and reported in Nephelometric Turbidity Units (NTU). pH measured by glass electrode using pH portable meter (HT-1202). The electrical conductivity was determined by using EC portable meter (ADWA AD31). The concentration of total

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suspended solids (TSS) was determined according to Standard methods 2540 D by filtering a given amount of water sample through a vacuum filter, a filter paper is used (squared; 0.45 µm pore size, 47 mm diameter) was used. Filter papers were previously dried at 105°C for 3 hours in a drying oven and were measured by analytical scale, then after filtration dried again as described above. We got the amount in mg/l by the subtraction of the weight measured before filtering from the weight measured after filtering.

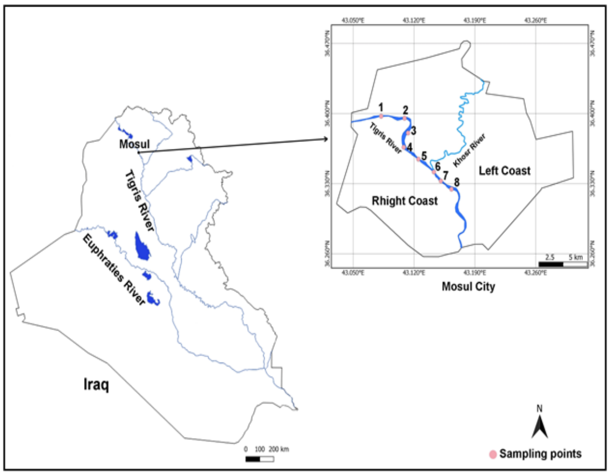

Fig .1. Map showing the water samples in Tigris River within Mosul city.

3. Statistical analysis

Data collected was statistically analyzed by using R statistical program for producing the graphs and calculating (correlation and p-value), and used QGIS program to produce the Interpreted maps in Figure 4 and the map in Figure 1.

Table 1. GPS coordination for the sampling points for Tigris River inside the city of Mosul.

Sampling points	Latitude	Longitude
1	36°23'51.4"N	43°04'56.8"E
2	36°23'44.6"N	43°06'33.7"E
3	36°22'51.4"N	43°06'48.2"E
4	36°21'58.1"N	43°06'28.4"E
5	36°21'17.2"N	43°07'28.9"E
6	36°20'31.2"N	43°08'35.1"E
7	36°19'56.8"N	43°09'01.8"E
8	36°19'29.5"N	43°09'47.9"E

4. Results and discussion

The Turbidity and total suspended solids TSS could be easily used for indicating water quality because they are the most visible indicators for water. The particles of suspended solids can come from runoff, discharges, soil erosion, stirred bottom sediments or algal blooms [14, 6]. The clarity of water has generally been used as an indicator of healthy water, whereas a sudden increase in turbidity in a previously clear water body could be used as a cause of concern. The temperature varied during the sampling period, in April the air temperature was (35 C0) and the water temperature was (15 C0), During May the air temperature was (44 C0) and the water temperature was (17 C0), in July the air temperature was (48 C0) and the water temperature was (22 C0), at October the air temperature was (33 C0) and the water temperature was (20 C0), and in December the air temperature was (12 C0) and the water temperature was (11 C0). Higher water temperatures in turbid water bodies could increase the evaporation of the water and hence decrease the volume of the water in the water bodies [15]. In the current study, there was no significant relationship between air temperature or water temperature and turbidity (r= -0.11, p= 0.5).

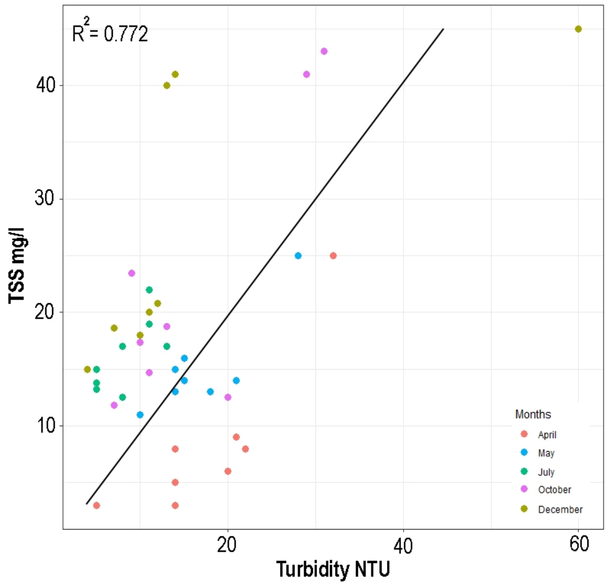

Fig.2. Relation between turbidity (NTU) and TSS (mg/l) for water samples collected in Tigris River at Mosul during five months.

The turbidity and total suspended solids showed a temporal variation for the eight locations examined in the Tigris River in Mosul along five months in 2021. There was a good linear relation (R2 = 0.75) between turbidity and TSS (Fig. 2) with a significant correlation (r= 0.53, p= <0.05) for water samples taken during the five events (April, May, July, October, and December 2021). The turbidity and TSS range of 35 - 4 NTU and 45 - 3 NTU respectively. Whereas the highest value of turbidity of 35 NTU was during December sampling period, and 45 mg/l was for TSS during December also.

The (Fig. 3) showed a significant positive relation between the turbidity and total suspended solids TSS for all the days measured in the Tigris River in Mosul. A significant positive correlation (r= 0.85, P-value= <0.05) was between turbidity and TSS in April sampling period during spring season. At May sampling period a significant positive correlation (r= 0.84, P-value= <0.05) established between turbidity and TSS in spring season. A positive correlation (r= 0.69, P-value= 0.054) between turbidity and TSS in July sampling period in summer season. A significant positive correlation (r= 0.82, P-value= <0.05) between turbidity and TSS in October sampling period in fall season. And during December sampling period a significant positive correlation (r= 0.68, P-value= 0.06) between turbidity and TSS in winter season.

On April the average value was (18.75 NTU) for turbidity, whereas location 1 recorded the highest value of (33 NTU) of turbidity, and least value of (4 NTU) were recorded in the location 2 (Table 2). In May the average value of turbidity was (17.87 NTU), the location 1 recorded the highest value of

(29 NTU) of turbidity, while the lowest value (11 NTU) for turbidity were recorded in the location 4 (Table 1). During July the average value was (9.25 NTU) for turbidity, whereas the highest value of (14 NTU) for turbidity was in location 8, and the lowest value of (6 NTU) was recorded in the locations 2, 4, and 6 (Table 2). In October the average value of turbidity was (17.25 NTU), the highest values of (30 NTU and 32 NTU) for turbidity was recorded in the locations 2 and 6 respectively, while the lowest was (8 NTU) for turbidity in the location 8 (Table 2). in December sampling period the average value was (17.25 NTU) for turbidity, the highest value of turbidity was (60 NTU) in the locations 4, and the lowest value of (5 NTU) of turbidity was recorded in the location 1 (Table 2).

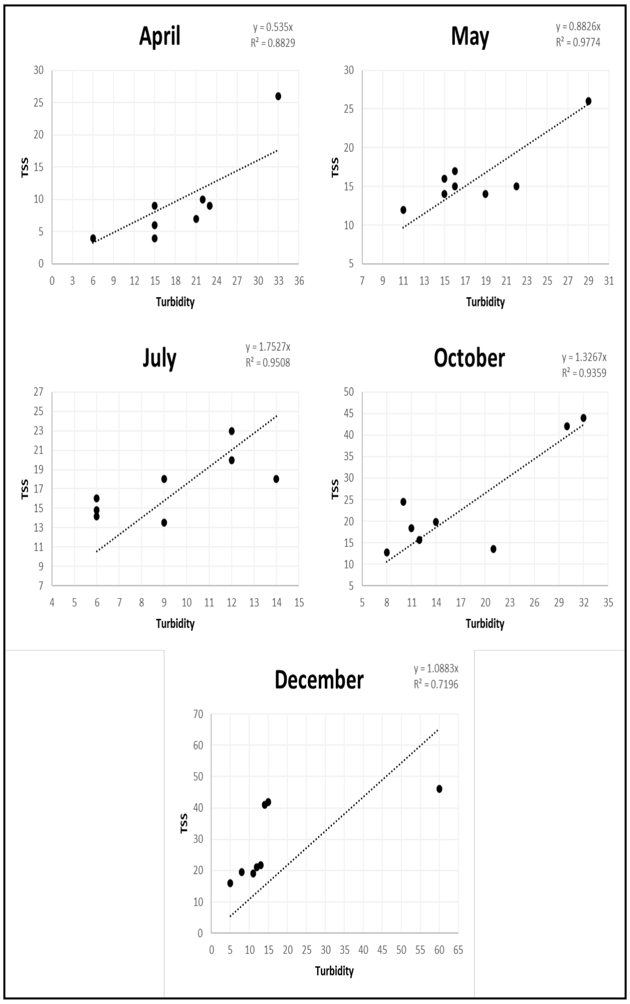

Fig.3. Graphs showing the relationship between Turbidity and TSS in Tigris River in Mosul city the five months.

The average value of TSS was (9.37 mg/l) during April sampling period, the highest amount of (6 mg/l) in the location 1, and the lowest was (6 mg/l) at the location 2 (Table 2). During May sampling period the average value was (16.12 mg/l), the highest value of (26 mg/l) was recorded in the location 1, whereas the least value was (12 mg/l) was in the location 4 (Table 2). During July sampling period the average value was (17.18 mg/l), the highest value of (23 mg/l) was recorded in the location 1, whereas the least value was (13.5 mg/l) was in the location 3 (Table 2). During October sampling period the average value was (23.83 mg/l), the highest value of (44 mg/l) was recorded in the location 6, while the lowest value was (12.8 mg/l) in the location 8 (Table 2). The average value at December sampling period was (28.3 mg/l), the highest value of (46 mg/l) was recorded in the location 8, while the lowest value was (12.8 mg/l) in the location 1 (Table 2).

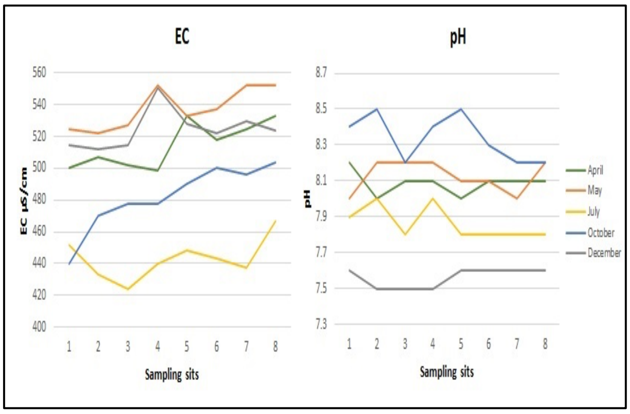

Fig.4. Graphs showing the variation of pH and Electrical Conductivity EC for the water samples within Tigris River in Mosul.

During April sampling period, the maximum amount of electrical conductivity EC was (533 µS/cm) in the location 8, and the lowest was (499 µS/cm) at the location 4 (Fig. 4). In the sampling period of May, the highest EC value of (552 µS/cm) was recorded in the locations 7 and 8, and the lowest value was (522 µS/cm) was in the location 2 (Fig. 4). In July sampling period the highest EC value of (467 µS/cm) was recorded in the location 8, whereas the least value was (424 µS/cm) was in the location 3 (Fig. 4). The highest value of EC during October sampling time was (504 µS/cm) in the location 8, while the lowest value was (440 µS/cm) in the location 1 (Fig. 4). In December sampling period the highest EC value of (551 µS/cm) was recorded in the location 4, while the lowest value was (512 µS/cm) in the location 2 (Fig. 4).

The pH data of the sampling sites shows almost invariance maintaining the neutrality of water through all months of the sampling period. The pH values of water samples of the study area varied between (8.2 - 8) in April and May (Fig. 4). At July decreased and it was varied between (8 - 7.8) in the sampling sites (Fig. 4). The pH increased during October (Fig. 4) and it was varied between (8.5 - 8.2). While it was decreased again and varied between (7.6 - 7.5) during December sampling period (Fig. 4).

Water is a very important factor for life after air, no single human can live without the need for water, about 60% of the average human body consists of water in the sense that human life needed clean water every day [12]. The turbidity and total suspended solids (TSS) of water in rivers could be affected by so many different factors. These factors can be from natural factors, which could be caused by heavy rainfall, landslides, mudslides, as well as human activities, could be pollution discharge and construction engineering [13].

The water quality for the Tigris River could be represented by turbidity and total suspended solids TSS as physical parameters, where they were varied while the river enters and leaves the city during the four seasons. The lowest amount of Turbidity and TSS generally was within summer season in July sampling period, and the highest was during autumn and winter seasons at October and December (Fig. 4). During the spring season in (April and May), the Turbidity and TSS value of the river was high when the river entered the city, while the turbidity and TSS values decreased when the river exited from it (Fig. 4). In summer the turbidity and

TSS were at the lowest values either while it entered or left the city in July. The amount of turbidity and TSS of the river was at the lowest during autumn and winter seasons when it enters the city, but the values increased due to rains that that falls in October and December. Surface water, especially in rivers during the rainy season could has a high level of turbidity [11]. Moreover, another factor affects the values was related to Al-Khosr River that increased the turbidity and TSS of Tigris River in October in the location 6. While location 2 during October sampling period showed increasing in turbidity and TSS due to some dredging activities in the river at that time. At location 4 there was increasing in turbidity and TSS which caused from direct discharged of non-treated sewage from the right coast region of the city at December.

Table 2. Table showing parameter values for Turbidity NTU, TSS mg/l, pH, and Electrical Conductivity µS/cm for Tigris River in Mosul during five months period.

Months	Parameters	1	2	3	4	5	6	7	8	Median	Max	Min	St.dev
April	Turbidity	33	6	22	21	15	23	15	15	18	33	6	7.94
	TSS	26	4	10	7	6	9	4	9	8	26	4	7.09
	Ph	8.2	8	8.1	8.1	8	8.1	8.1	8.1	8.1	8.2	8	0.06
	EC	500	507	502	499	533	518	525	533	512.5	533	499	14.49
May	Turbidity	29	16	22	11	16	19	15	15	16	29	11	5.51
	TSS	26	17	15	12	15	14	16	14	15	26	12	4.23
	Ph	8	8.2	8.2	8.2	8.1	8.1	8	8.2	8.15	8.2	8	0.09
	EC	525	522	527	552	533	537	552	552	535	552	522	12.86
July	Turbidity	12	6	9	6	9	6	12	14	9	14	6	3.15
	TSS	23	14.8	13.5	14.2	18	16	20	18	17	23	13.5	3.22
	Ph	7.9	8	7.8	8	7.8	7.8	7.8	7.8	7.8	8	7.8	0.09
	EC	452	433	424	440	448	443	437	467	441.5	467	424	13.02
October	Turbidity	14	30	10	21	11	32	12	8	13	32	8	9.33
	TSS	19.8	42	24.5	13.5	18.4	44	15.7	12.8	19.1	44	12.8	12.40
	Ph	8.4	8.5	8.2	8.4	8.5	8.3	8.2	8.2	8.35	8.5	8.2	0.20
	EC	440	470	478	478	490	500	496	504	484	504	440	20.72
December	Turbidity	5	14	11	60	12	8	13	15	12.5	60	5	17.58
	TSS	16	41	19	46	21	19.6	21.8	42	21.4	46	16	12.37
	Ph	7.6	7.5	7.5	7.5	7.6	7.6	7.6	7.6	7.6	7.6	7.5	0.05
	EC	515	512	515	551	528	522	530	524	523	551	512	12.47

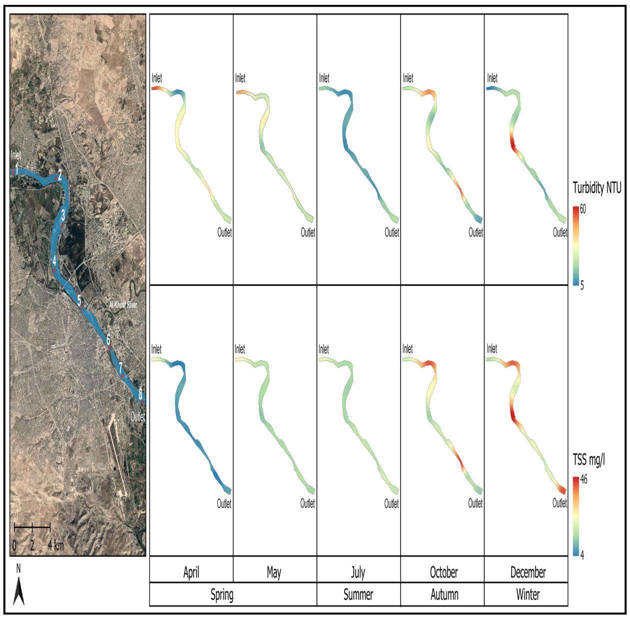

Fig.4. Interpreted maps showing the changes of Turbidity and TSS along the Tigris River in different months in Mosul city.

Table 3. Selection of some physical parameters from World health Organization WHO guidelines for safe drinking water [10].

Parameters	Permissible Limits (by WHO)
Water Temperature	30
PH	6.5 – 8.5
Turbidity	1-5 NTU
Conductivity	> 400 µS/cm
Total suspended solids	> 10 mg/l

5. Conclusion

It is believed that within Mosul city a lot of sources of pollution sources from industrial and agricultural activities drain the effluents inside the river from the both right and west coasts [9]. The average temperature of water samples of the study area was (17 C^0) and in the range of (11.7–22.5 C^0). Temperature according to the permissible limit of WHO (30 C^0). The EC value was (424–552 µS/cm) with an average value of (500 µS/cm), which exceeded the WHO Permissible Limits for drinking water. According to WHO standards, EC value should not exceed (400 µS/cm). The pH during the investigation ranged between (7.5–8.5) which are in the range of WHO standards. The maximum permissible limit of pH by WHO was recommended from (6.5 to 8.5). The mean turbidity value obtained for Tigris River in Mosul (16 NTU) is higher than the WHO recommended value of (1 - 5 NTU). The Turbidity was beyond the WHO recommended standard of drinking water due to the organic load that was in the river because of the effluents drainage without treating from the two coasts of the city. While average value of the total suspended solids during the investigated period was (19 mg/l) which exceeded the WHO Permissible Limits for drinking water. According to WHO standards, TSS value should not exceed (10 mg/l).

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