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A Study of Some Physical and Chemical Properties of the water of the Tigris River within the city of Mosul, Iraq

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ABSTRACT

The Tigris River is the main water resource for the city of Mosul, so the current study was conducted on the Tigris river section within the city of Mosul, which included some physical and chemical properties of the waters of the Tigris River, starting from the Kubba site in the north to the Yarmajah site in the south, and comparing it with international indicators within the river section. The results of the study showed that the water of the Tigris River passing through the city of Mosul ranges from neutral and tilted towards light base, and that the average water temperature ranged between (16.1-16.6) °C, and that the values of electrical conductivity of the river water fall within the average effect of the permissible limits for use Water, and that the waters of the Tigris River fall within the excellent waters according to the turbidity. The results also showed that the water of the Tigris River is well ventilated, as the average values of dissolved oxygen ranged between (8.3-9.3) mg/l and the rates of total dissolved solids values for the water of the Tigris ranged between (167-199) mg/l. The levels of the BOD_5 concentrations were within the permissible limits specified by the World Health Organization for drinking water. The results showed that the water of the Tigris River is hard. The ions of nitrates, orthophosphates, sulphates and chlorides showed a variation in their concentrations during the months of the study. The levels of sodium and potassium ions ranged between (19.9-24.6) and (2.6-4.2) mg/l, respectively.The effective silicate levels in the river water reached (5.8-8.5) mg/l, and the alkalinity concentrations in the Tigris water decreased due to the dilution and diffusion factors.

Key words : *River water quality, Tigris river, Iraq*

Introduction

Water is one of the basic elements of life that must be provided and preserved. Therefore, most civilizations and cities are established in places where water is available (Al-Kubaisi and Ibrahim, 2004). Although most of the surface of the Earth is water, the percentage of fresh water is only (3%), which makes this resource very limited (Aljoborey, 2020).

Water pollution is one of the global problems, especially inland water pollution such as rivers, lakes, and others (Nashat *et al.*, 2017).

The Tigris River is one of the important fresh water resources in Iraq, which Stems from the southeastern parts of Turkey (Al-Akam, 2016), and which, during its passage through the city of Mosul, the largest city in northern Iraq, is exposed to the arrival of various types of pollutants in quantity and quality, which reach it through the estuaries that are located on The two banks of the river in the city, such as the liquid residential and industrial wastes, and the lack of interest in treating the waste before it is

thrown into the riverbed, which may affect the physical, chemical and biological properties of the Tigris River (Al-Yazji and Mahmoud, 2008; Al-Aqili *et al.*, 2017).

Many studies have been conducted on the Tigris River within the city of Mosul, but most of them dealt with the left or right sides of the river, including the study of Al-Sarraj study (2019), which dealt with the study of some physiochemical properties of the Khosr River estuary and their impact on the quality of the Tigris River water within the city of Mosul, its findings indicated that the river water in the city of Mosul is still within the Iraqi specifications for the protection of water resources No (25-A1) For the year 1967.

Kanna and his group (2019) reached the ability of chara sp.to absorb nickel, one of the heavy metals polluting the environment at about 1.60 and 7.47mg/kg respectively. As for Al-Sarraj and Janker (2020) we have concluded that heavy metals polluting the water of the Tigris River have arole in inhibiting the effectiveness of collinesterase for the two types of fish.

The present study aims to know the quality and characteristics of the water of the Tigris River by measuring the variation in the physical and chemical characteristics of the waters of the Tigris River passing through the city of Mosul.

Materials and Methods

Water samples were collected from the studied sites from August of 2020 until January 2021 on a monthly. The study area included the Tigris River, starting from the Kubba area in the north to the Yarmajah area in the south. Five main sites were selected along the course of the river within the city, and each site was divided into three secondary sites which are (the right bank, the left bank and the middle of the river) and the sites are:

- The first location: the water of the river at the Kubba area.
- The second location: the water of the river in the Rashidieh region.
- The third site: the waters of the Tigris River at the third bridge (Al-Shuhada Bridge).
- Fourth site: the river waters after the Freedom Bridge.
- Fifth site: the waters of the river, the beginning of the Yarmorga area. As in the Figure 1.

Results and Discussion

The following examinations were performed using the methods provided in (APHA, 2017)

Air temperature

The average air temperature during the study period ranged between (17.5-8.3) °C , as in Table (1). The reason is due to the seasonal change and the nature of the climate in Iraq, which is characterized as extreme and highly volatile, as it differs between day and night and between summer and winter.

Fig. 1. A map Showing The Study Sites

Water temperature

The average water temperature ranged between (16.1-16.6) ° C as in Table 1 during the study period, and the reason may be attributed to the daily change in temperature, as the water temperature is affected by the air temperature (Al-lami *et al.*, 1997), where the highest temperatures were recorded during the month of August of 2020, which reached (20) °C, while the lowest temperature was in the month of January for the year 2021, which reached (10) °C, and that this difference is due to the seasonal change of air temperature, which It is reflected in the temperature of the water. These results are close to the findings of (Al-Hadidi, 2017), where it noticed that the lowest temperature was 12 ° C and the highest was 23.5 °C.

pH

The results showed that the river's water ranges from neutral and tilted towards the basicity, and its rates ranged between (7.3-7.5). This may be attributed to the drainage of sewage water without treatment into the river during its passage through the city. The results of the current study agree with the findings of (Al-Barawi, 2004; Tali'i and Al-Barhawi, 2000) with the knowledge that most of the natural waters tend towards the basicity slightly due to the presence of carbonate and bicarbonate ions (APHA, 1998).

Electrical conductivity (EC)

The results of the rates of electrical conductivity measurements of the Tigris water samples during the study period reached between (320-401) microsimens / cm, in that the increase in the value of the electrical conductivity may be estimated to increase the excretion of salts with sewage and increase the activity of micro-organisms in the decomposition processes (Al-Jahsani, 2003; Amadi *et al.*, 2010). As for the decrease in electrical conductivity, it may be due to its being affected by mitigation and diffusion factors (Al-Sarraj, 2019). The values of electrical conductivity of the Tigris River water in the studied sites may fall within the average effect of the permissible limits of water use. Based on the (NHVRAP, 2011).

Turbidity

The results of the study showed that the highest rate of turbidity in the river water samples reached (5.6) N.T.U during the study period, and the reason is due to the presence of organic matter and contaminated suspended matter, in addition to the high water levels in the river (Al-Sarraj, 2019). When comparing it with the determinants as in (Table 3), which illustrates the scale of water clarity in terms of turbidity (Water Watch, 1997), we note that the water of the Tigris River during the study period falls within the excellent waters according to turbidity, and these results are consistent with what each of (Alrawi, 1999; Al-Singari, 2001) in their environmental study of the waters of the Tigris River in the city of Mosul.

Dissolved oxygen (DO)

The lowest concentration of dissolved oxygen in the Tigris water samples during the study period was (8.3) mg / l. The reason may be due to the increase of pollutants in the river water and its decomposition by the action of aquatic organisms that decompose organic matter, which leads to the creation of unfavorable conditions for the life of some aquatic organisms (Alam *et al*., 2007), while the highest concentration of dissolved oxygen is observed (9.3). mg / l and the increase in DO concentration may be due to good aeration, velocity of current and continuous mixing, as well as the density of aquatic plants (Lamy *et al*., 2002; Hassan, 2004).

Total Dissolved Solids (TDS)

The average values of total dissolved solids of the Tigris water during the study period ranged between (167-199) mg / l as in Table 1 and these results illustrate the effect of throwing agricultural waste as well as domestic and industrial wastes into river water, which is the cause of pollution Water with total dissolved solids (Al-Asadi *et al*., 2006).

Biochemical Oxygen Demand (BOD_5)

The levels of the concentrations of BOD_5 ranged between (1.5-2.4) mg/l in the waters of the Tigris River during the study period, and the reason for the increase in the BOD_5 values may be due to the increase in organic waste that is discharged into the river from the estuaries spread on the left and right side of the Tigris and Al-Saadi, 1995), while the decrease in the BOD_5 value is due to the fact that the river water has a low temperature and high dissolved oxygen concentrations in it, as the value of the oxygen Bio requirement is directly proportional to the amount of organic matter and inversely to the dis-

solved oxygen concentration (Winner, 2000). The levels of BOD concentrations within the permissible limits specified by the World Health Organization for drinking water were less than (3) mg/l, and the results of the current study differed with the findings of (Al-Hadidi, 2017), which found that the range was between (0.3-5.5) mg/l while agreeing with the findings of (Al-Rawi, 1999), who found that the range was between (1.5-2.7) mg/l.

Total hardness, Calcium and Magnesium hardness (TH, CaH and MgH)

The results showed that the rates of total hardness values in the studied sites of the water of the Tigris River during the months of the study ranged between (152.5-179.1) mg/l in terms of calcium carbonate, so the water of the Tigris River is hard according to the water classification system as mentioned in (Todd and Mays, 2005), and this is due to the industrial, human and agricultural wastes that are added to the river and what the estuaries discard on both sides of the river through the sewers offered to it (Al-Rawi, 1999; Khuwaidem, 2012). As for calcium hardness, its highest rate was (125.0) mg / l in terms of calcium carbonate, and it exceeded the limits permitted by the World Health Organization of (75) mg/l, while magnesium hardness ranged between (54-71) mg/l. liter in terms of calcium carbonate and it is within the limits permitted by the World Health Organization of (125) mg /l. The results of the current study are close to what was reached by (Al-Sarraj, 2013), where it was noted that the range ranged between (192-294) mg/l, and the water of the Tigris River is very hard in some locations and hard in others.

Nitrate ion NO_3^{-1}

Nitrate ions showed a variation in their concentrations during the months of the study, and this may be attributed to agricultural and civil activity, in addition to that the high concentrations of nitrates may be due to increased organic decomposition (Zamili, 2007). The rates of nitrate concentrations ranged between (0.04-0.17) mg/l. The decrease in nitrate concentrations in river water may be attributed to its consumption by the floating plants and algae present in the area (Al-Hamdani, 2010b).

Orthophosphate ion PO_4^{-2}

The average orthophosphate ion concentrations over the study period were between (0.51-1.13) mg /l as shown in Table 1, and this is due to the wastewater discharged into the river, as the phosphate concentrations in the residential water waste of the city of Mosul reach (10) mg/l (Al-Rawi, 1999), in addition to contamination of the water with washing powders and detergents with high concentrations of phosphates that are discarded into the river without treatment (Khudair, 2013), as well as the river's passage of large agricultural lands that use phosphate fertilizers for fertilization. These results converge with the findings (Al-Hadidi, 2017) that the orthophosphate concentrations have exceeded the limits permitted by the World Health Organization of (0.5) mg/l.

Sulfate ion SO_4^{-2}

The rates of sulfate concentrations in the river water ranged between (36.9-76.8) mg/l, and this may be due to the gypsum nature of sedimentary rocks, which is a direct source of dissolved sulfates in natural waters, in addition to the use of fertilizers containing sulfates, especially in the cultivation season (Talak, 2004). The results of the current study agree with the findings of (Al-Hadidi, 2017) that the sulfate ion concentrations fall within the limits permitted by the World Health Organization of (250) mg/ l.

Chloride ion Cl

The levels of chloride ion concentrations during the study period ranged between (8.9-14.6) mg / l, and these results are consistent with what was found (Al-Sarraj and others, 2014) that they are within the limits permitted by the World Health Organization of (250) mg/l. The increase in chloride ion concentration in the Tigris River water is attributed to the containment of domestic, industrial and agricultural wastewater, and the effluent sewage water in high levels (Duggal, 2008).

Total Alkalinity

The rates of base concentrations during the study period were between (92-97.3) mg / l, and the discarded water and wastes reaching the river are the main source of the base due to the dissolution of organic materials and the production of carbon dioxide, which in turn will lead to the formation of bicarbonate and increase the regulatory capacity (Buffering capacity). The water of the Tigris River (Mustafa and Jankir, 2007). The results are consistent with what was found (Al-Hadidi, 2017) that basal con-

centrations decreased in the waters of the Tigris River within the city of Mosul due to mitigation and diffusion factors.

Silica SiO_2

The average values of silica in the waters of the Tigris River during the study period ranged between (5.8-8.5) mg/l, where silicon comes in second place after oxygen in terms of abundance in the earth's crust and appears in the form of (silica) oxide in sand and quartz and is united with minerals on The form of complex silicon minerals, especially igneous rocks, and on this basis it is expected that this compound is present in most natural waters (Reid, 1961). while (Al-Jubouri, 2009) noted that the values of silica in the waters of the Tigris River in Salah al-Din Governorate ranged between (1.92-20.94) mg of silicon atom - silica per liter.

Sodium ion Na^+

The results of the current study showed that the levels of sodium ion concentrations in the waters of the Tigris River ranged between (19.9-24.6) mg / l. The reason for this increase may be attributed to the various quantities that are added to the river from household waste, and the impact of neighboring agricultural lands that increase the concentration of this element in the water These results are consistent with The finding of (Al- Sarraj, 2013; Al-Mashhadani and Al – Sinjari, 2007). It did not exceed the limits permitted by the World Health Organization (250) mg / l, as it was found that the range was between (18.2-33) and (13.43-37.67) mg / l respectively.

Potassium ion K^+

Potassium ion is present in surface waters in low concentrations, because the rocks that contain resistance to weathering processes are usually less than (10) mg/l (Al-Sarraj *et al*., 2014). The lowest rate of potassium concentrations during the study period was (2.6) mg/l, while the highest rate was (4.2) mg / l, and the reason for the high levels of potassium during the course of the river inside the city is due to what the river receives from the outfall of liquid wastes during His flow (Al- Rawi, 1999; Al-Sarraj, 2013). This study concurs with what was found (Talaat, 2012), that it did not exceed the limits permitted by the World Health Organization of (12) mg / l.

The BOD5 values decrease at non-polluted sites of the river, and increase as the amount of pollutants reaching the river increases. The results showed that most of the salts, compounds, and elements of ions and others increase during the flow of the river in the city of Mosul, affected by the discharge of waste-

Table 1. Shows The rates of Physical and Chemical Properties at The studied sites during the study period

Site/Bank	Air Tmp. C°	Water Tmp.C°	pH	E.C (µs/cm)	TDS (mg/l)	D.O (mg/l)	T. Alkalinity (mg/l)	Turbidity (NTU)	K^+ (mg/l)	Na^+ (mg/l)
Sit 1										
Left	17.5	16.3	7.5	367	184	9.3	92	4.3	2.7	22.9
middle	17.5	16.3	7.5	366	183	9.2	93.3	4.7	2.6	21.1
Right	17.5	16.3	7.5	366	183	9.1	97.3	4.8	2.8	20.5
Sit 2										
Left	17.5	16.3	7.4	320	167	9	95.6	3.5	3.2	21.8
middle	17.5	16.3	7.5	360	183	8.9	92.3	3.1	2.9	20
Right	17.5	16.1	7.5	348	179	8.7	95.3	3.5	2.8	20
Sit 3										
Left	17.5	16.3	7.4	371	188	8.7	94.6	3.8	3.8	22.3
middle	17.5	16.3	7.4	367	186	8.9	96	4.6	2.6	19.9
Right	17.5	16.1	7.4	367	188	8.3	93	2.0	3.0	20.5
Sit 4										
Left	18	16.3	7.3	401	199	8.3	95.3	3.5	4.2	23.3
middle	18.1	16.3	7.4	377	188	8.6	95	5.4	3.2	21.1
Right	18.1	16.1	7.3	378	190	9.0	93.6	3.3	2.7	21.5
Sit 5										
Left	18.3	16.6	7.4	379	188	8.8	94.6	4.4	3.7	23.8
middle	18.3	16.3	7.4	382	192	8.7	94.3	3.9	3.2	23
Right	18.3	16.6	7.4	395	199	8.5	94.6	5.6	3.3	24.6

Appendix Table (1)

Site/ Bank	BOD_5 mg/l	NO_3^- mg/l	PO_4^- mg/l	SO_4^- mg/l	SiO_2 mg/l	Cl^- mg/l	T.H mg/l	Ca.H mg/l	Mg.H mg/l
Sit 1									
Left	1.7	0.11	0.54	43	7.0	9.4	152.5	90.6	61.8
Middle	1.7	0.07	0.79	36.9	7.2	10.8	153.3	95.5	57.8
Right	2.4	0.07	0.51	55.4	6.9	10.8	166.6	100	66.5
Sit 2									
Left	1.9	0.09	0.56	56.3	7.4	14.1	169.1	104	64.6
middle	2.4	0.04	0.71	48.5	7.3	10.3	163.3	99	64.3
Right	2.3	0.05	0.55	67.1	7.8	11.6	160.8	89.8	71
Sit 3									
Left	1.5	0.07	0.63	61.2	7.2	12.6	177.5	119.5	58
middle	1.8	0.06	0.68	68	5.9	12.8	175	115	60
Right	1.6	0.08	0.62	52.1	7.6	8.9	170	109.3	60.6
Sit 4									
Left	2.2	0.06	1.04	63.8	8.4	14.6	176.6	108.5	68.1
middle	1.6	0.04	1.04	68.2	7.8	11.4	168.3	111	57.1
Right	2.0	0.17	1.13	69.2	8.5	12.3	177.5	114	63.5
Sit 5									
Left	1.9	0.09	0.69	76.0	6.8	12.4	176.6	116.6	60
middle	2.6	0.04	0.93	76.8	8.1	12.9	175.8	121.1	54.6
Right	1.6	0.09	1.04	72.2	5.8	12.3	179.1	125.0	54

water into the river inside the city, and then decrease again due to the factors of dilution and diffusion. The waters of the Tigris River are classified, based on the phosphorous concentrations in the water, as being highly nutrient-rich, based on the classification mentioned in Helsel and Muller (1999).

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