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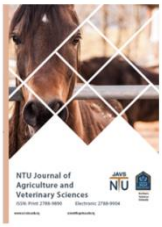

Qualitative characteristics of the water of the Tigris River for two sites in the city of Mosul

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A B S T R A C T

Changing the quality characteristics of water directly affects human health , living organisms, physical and chemical properties of the soil, and affects crop yield. Two sites were chosen to collect samples, the first in the village of Sharekhan which is the last point through which the Tigris River passes before entering the city of Mosul, which is located northwest of the city of Mosul .The second site was in village of Al-Busif south of Mosul to compare the seasonal change in the Qualitative characteristics of the water between the two sites.The results indicated an increase in most of the studied characteristics in the summer and autumn season compared to the winter and spring seasons due to the variation in rain rates and temperatures between the seasons. water in Tigris River at the Sharekhan site for all the studied characteristics was of higher quality than that was taken from the Al-Busif site to be used for the purposes of (human drinking, plant irrigation, livestock and poultry watering, and fish life). This can attributed to the effect of liquid waste loaded to the River as it passes through the city of Mosul.

Introduction

Water comes in the second place after air in terms of vitalty to the life of living organisms. Water quality is defined as the physical, chemical and biological characteristics of water required for the continuation of the life of living organisms, such as temperature, color, taste, concentration of salts and ions dissolved in the water, dissolved oxygen, pollutants, bacteria, fungi and viruses [1].

Changing the qualitative characteristics of water directly affects human health and living organisms [2], Many farmers suffer from a lack of suitable water for irrigation to meet the needs of agricultural land due to changes in its qualitative characteristics. Poor quality or polluted water has a negative impact on the physical and chemical properties of the soil and affects crop yield [3].

Large quantities of liquid waste are thrown into Tigris River in the city of Mosul without treatment, and the dumping of these wastes leads to water pollution and reduces its quality for various uses. The volume of these wastes is estimated at about 500,000 m3/day [4].

Many studies indicate the poor water quality of the Tigris River towards south Mosul Due to the discharge of liquid waste into it during its passage through the city of Mosul , The water quality of the Tigris River at the Al-Busif site was lower compared to the Rashidiya site, such as electrical conductivity, total dissolved salts, suspended materials and concentration of nitrates, phosphates, and heavy metals [5]. Therefore, this study came to compare the seasonal change in the characteristics of the water of Tigris River between Sherekhan and Al-Bousif areas and evaluate it According to international standards for the purposes of its use: drinking , irrigating plants , watering animals , and fish life.

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Materials and methods

1.Study area: Two sites were chosen to collect samples, the first in the village of Sharekhan which is the last point through which the Tigris River passes before entering the city of Mosul, which is located northwest of the city of Mosul and second site was in village of Al-Busif south of Mosul shown in Figure (1). The distance between the two sites is about 22 km. Samples were taken monthly for each site for a full year between March 2022 to February 2023. They were collected using plastic bottles that were washed with sample water and taken from the middle of the river. Drops of toluene were added to it to stop the growth of fungi, and nitric acid was added for not to precipitate heavy metals, then it was transported to laboratories of the College of Agriculture at the University of Mosul.

2.Field and laboratory analyzes: water temperature was measured in the field during the sample collection process using an electronic scale. Total solids, dissolved oxygen, pH and electrical conductivity were also measured using portable field devices [6]. The total hardness of the water samples was estimated by taking 25 ml of the water sample and adding the ammonium chloride buffer solution, then calibration it with EDTA (0.02 N) using drops from the E.B.T Indicator. The turbidity was estimated using the Turbidity device through the intensity of the light spreading in the sample, and the nitrate concentrations were estimated using the Spectrophotometer device At a wavelength of 206 nanometers, phosphate ions were estimated using Color method. Then the absorbance of light was measured using a spectrophotometer at a wavelength of 690 nanometers, and Heavy metals (zinc, lead and nickel) were estimated Using an atomic absorption device [7].

Results and discussion

1.Temperature (c◦)

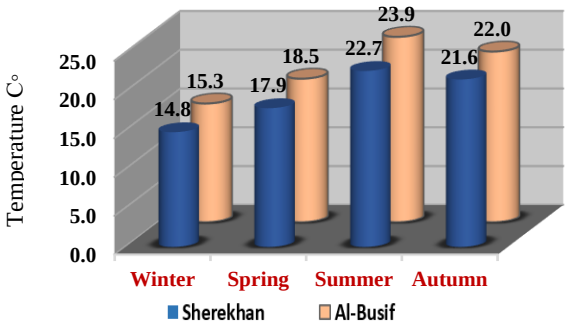
Figures 1. Aerial photo showing sample collection sites

Temperature affects the chemical and physical reactions of the water, as well as the microbial activity The growth of fungi increases with increasing temeratures,, and thus the quality of the water decreases and its suitability for drinking is affected. Water temperatures higher than (28) C◦ reduce the growth and reproduction of fish through their effect on the concentration of glucose in the blood and cortisol. And the number of red blood [8] , [9].

The results shown in Figure (2) indicats that the values of temperature in the water of Tigris River ranged between (14.8-23.9) C◦ .that the lowest temperature value was at the Sharekhan site in winter and the highest value was at the Al-Busif site in autumn .These differences are due to the difference in the time of measuring temperatures,

as the water temperature was measured at Sharekhan site first, then the Al-Busif site. Also, the discharge of cold deep water from the Mosul Dam caused a decrease a water temperature in Sharekhan site. Some studies have indicated that the natural thermal characteristics of river ecosystems depend on the water source, flow rate, and volume of water flowing from the tributaries, as well as climatic and topographical conditions, the size of the vegetation on both sides of the river and the shape and depth

cause for this increase is the effect of rain in the



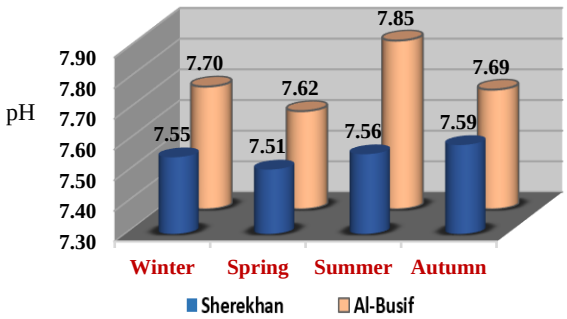
Figures 2. Seasonal Temperature C◦ in the Tigris River

2.pH

The decomposition of organic waste in water reduces the degree of reaction due to the formation of dissolved carbon dioxide Its increase creates physiological stress for living organisms, reduces reproduction or growth, causes many diseases, and reduces biodiversity in aquatic life [10].

The results shown in Figure (3) indicated that the values of pH in the water of the Tigris River ranged between (7.51-7.85) .the lowest value for pH was at the Sherekhan site in the spring and higher value at the Al-Bosif site in the summer This may be because the mixing of some basic chemical pollutants with the river water in Al-Bosif site.

The pH values of the Tigris River are slightly basic due to the carbonate and bicarbonate ions dissolved in it. The water of the Tigris River in the sites of Sharekhan and Al-Busif, according to its pH values,is considered suitable for use for drinking purposes, irrigating crops, watering livestock, horses, poultry, and fish life .



Figures 3. Seasonal average pH in the Tigris River water

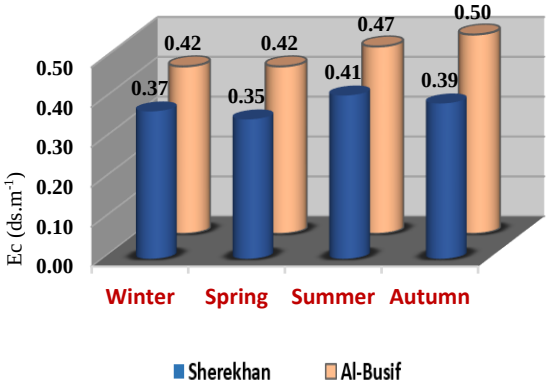
3.Electrical conductivity (EC)

It is to measure the ability of water to pass electrical current through it due to dissolved salts and other inorganic substances. The electrical conductivity of water increases with increasing salinity, which causes health problems for humans, plants, and living organisms [11].

The results shown in Figure (4) indicated that the values of electrical conductivity in the water of the Tigris River ranged between (0.35-0.50) ds.m-1 .the lowest value was at the Sharikhan site in the spring, and the highest value was at the Al-Bosif site during the autumn.

The higher electrical conductivity values was at Al-Bosif site compared to that of Sherekhan site in all study seasons. It is due to the discharge of liquid waste into the Tigris River in the Mosul during the distance it travels to the Al-Bosif site, which leads to an increase in the loads of mineral materials.

The electrical conductivity values of the Tigris River water at the Sharekhan and Al-Busif sites are considered suitable for use for drinking and irrigation of crops.



Figures 4. Seasonal average electrical conductivity (ds.m^{-1}) in the Tigris River

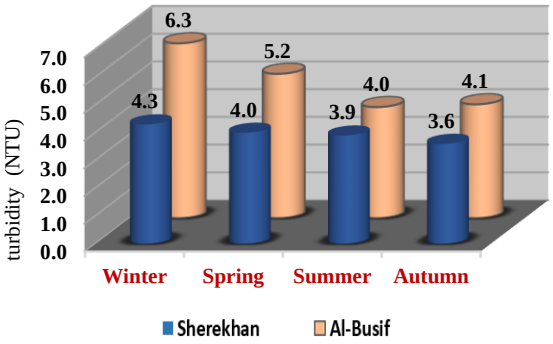
Table 1. International standards for the use of water for human drinking, plant irrigation, animal watering, and fish life

Parameters	drinking	Irrigation	watering animals			fish life	units
			livestock	Horses	poultry		
pH	6.5-8.5	-	-	-	6.8-7.5	6.5-9.0	
EC	400	2250	-	-	-	-	$ds.m^{-1}$
Turbidity	0.2	-	-	-	5	-	NTU
Total Hardness	500	-	-	200	180	-	$mg.L^{-1}$
Dissolved (DO) oxygen	5	-	-	-	-	-	$mg.L^{-1}$
Phosphate (PO_4^{-3})	-	-	-	-	-	-	$mg.L^{-1}$
Zinc (Zn)	4	2.0	50	25	1.5	0.12	$mg.L^{-1}$
Lead (Pb)	0.01	5.0	0.1	0.1	0.2	0.065	$mg.L^{-1}$
Nickl (Ni)	0.02	0.2	1.0	1.0	-	0.47	$mg.L^{-1}$
Source	[12]	[13]	[14]		[15]	[16]	

4.Turbidity

It is the amount of suspended matter in water, such as clay, silt, chemical sediments, organic materials, and living organisms, which cause water to change color. It is usually expressed in units (NTU) [12]. The results shown in Figure (4) indicated that the values of turbidity in the water of the Tigris River ranged between (3.6-6.3) NTU . the lowest value of turbidity was at Sharikhan site in autumn, and the highest value was at Al-Bosif site in winter.The cause for this increase is the effect of rain in the winter, which works to raise the river's water level and increase the speed of its flow, which works to increase the mixing of suspended materials, as well as organic matter and plant remains, and the drainage of rainwater from natural and artificial valleys into the river, which contains large amounts of suspended particles.In summer and autumn seasons, the flow of water and its level is low, therefore, clay particles, organic materials, and other suspended materials remain deposited under the surface of the water. Thus reducing turbidity.The water of the Tigris River at the sites of Sharekhan and Al-Busif is considered suitable for drinking in terms of its turbidity values.

Water turbidity can affect aquatic life as well as human health and life. It increases the growth. of algae and some aquatic plants because it does not allow sunlight to reach deeper into the water. Turbidity also increases the temperature of the water because The materials suspended in it that increase its absorption of heat [17].



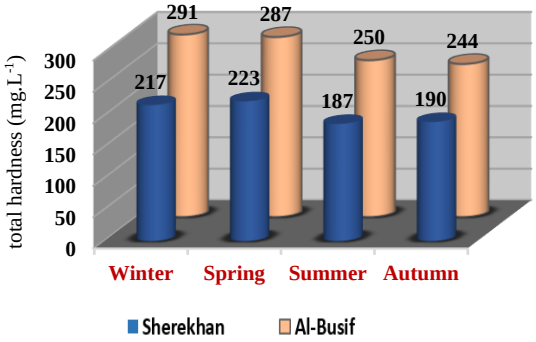
Figures 5. Seasonal average of turbidity (NTU) in the Tigris River water

5.Total Hardness

Hardness is the total concentration of double-charged cations in water, mostly calcium and magnesium ions, hard water does not foam with soap [18]. The results shown in Figure (5) indicated that the values of total hardness in the water of the river ranged between (187-291) mg.L-1, the lowest value was found at the Sharikhan site in summer, and the highest value was found at the Al-Bosif site in spring.Due to the effect of winter rains, which dissolve calcium

and magnesium salts in the soil, such as lime, gypsum,and dolomite, because most of the soils surrounding the Tigris River are considered calcareous or gypsum soils, which leads to an increase in the total hardness of the water.

The water of the Tigris River at Sherekhan and Al-Busif sites is suitable for drinking and has exceeded international standards for watering horses and poultry.

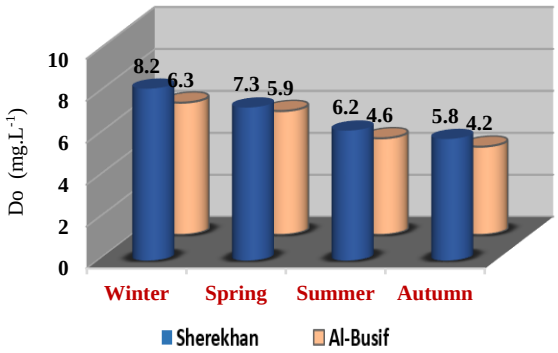


Figures 6. Seasonal average of total hardness (mg.L^{-1}) in the Tigris River water

6.Dissolved oxygen (DO)

The results shown in Figure (6) indicated that the values of dissolved oxygen in the water of Tigris River ranged between (4.2-8.2) mg.L^{-1}. The lowest value was found at the Al-Bosif site in autumn season, and the highest value was found at the Sharekhan site in winter season. This difference is due to the effect of the climatic seasons, as the concentration of dissolved oxygen in water increases as the temperature decreases due to its increased solubility in water. Also, lower temperatures in the winter work to reduce the activity of microorganisms that consume dissolved oxygen and release carbon dioxide gas due to their decomposition of organic materials in the water.

There is another effect of rain by increasing the water level of the Tigris River and increasing the speed of its flow, thus increasing the concentration of dissolved oxygen.Increasing the speed of water flow leads to an increase in the entry of atmospheric air and thus increasing dissolved oxygen levels, unlike still water, which has a lower rate of flow speed.The dissolved oxygen concentrations of the water of the Tigris River at the Sherikhan site are considered suitable for drinking, while the Al-Bosif site has exceeded international standards.Some studies have indicated that the concentration of dissolved oxygen in water affects the growth and species of aquatic organisms, and that the ideal dissolved oxygen concentration for fish life should be more than (5) mg.L^{-1}, and fish death generally occurs at concentrations less than (2) mg.L^{-1}1 Accordingly, the water of the Tigris River in the sites of Sharikhan and Al-Busif is suitable for fish life [19].



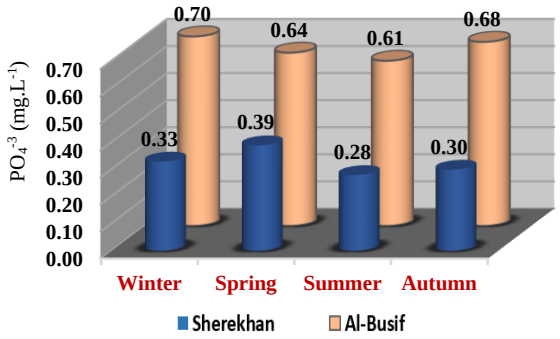
Figures 7. Seasonal average of dissolved oxygen (mg.L^{-1}) in the Tigris River water

7.Phosphate (PO_4^{-3})

Phosphorus is one of the basic nutrients for living organisms and aquatic life. It is one of the components of DNA and cell walls. It participates in energy transfer processes and is considered an essential element in the occurrence of the Eutrophication phenomenon which causes water pollution and reduces the quality of surface water for drinking and also affects aquatic life [20].

The results shown in Figure (7) indicated that the values of dissolved oxygen in the water of Tigris River ranged between (0.28-0.70) mg.L-1. The lowest value of phosphate concentration in the water of Tigris River was found at the Sharekhan site in summer, and the highest value was found at the Al-Bosif site in winter. This is due to the effect of rain that wash away soil particles from agricultural lands containing phosphorus compounds resulting from organic and chemical fertilizers and basic materials.

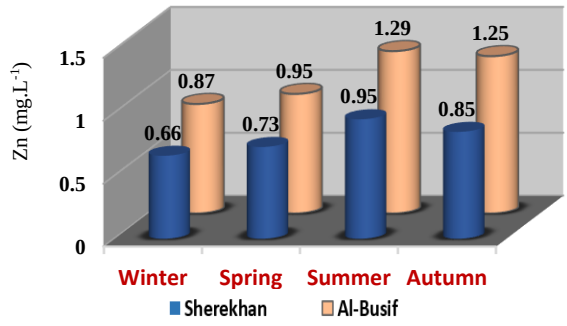
Concentrations of the water of Tigris River at the Sharekhan site are considered suitable for drinking and irrigation only, while at the Bosif site they exceed the locally permissible international standards for drinking and are suitable for irrigation.This may be due to the effect of rain, which strips the soil from agricultural lands containing phosphorus compounds resulting from organic and chemical fertilizers and soil source materials. Phosphate concentrations of the water of the Tigris River at the Sharekhan site are considered only suitable for drinking and irrigation, while the Al-Busif site has exceeded the international standards for drinking, but it is suitable for irrigation.



Figures 8. Seasonal average of Phosphate (mg.L^{-1}) in the Tigris River water

8.Zinc (Zn)

Zinc is an essential element in surface water and rivers. Zinc is found in every drinking water and is transferred to the water through dust from metal smelting plants, from weathering of soil minerals, erosion, and from the release of industrial polluted water, sewage, plant waste, fertilizers, and pesticides. Zinc gives an unwanted taste to the water when its concentration increases more than (4) mg.L-1, and a fatty layer is also formed when boiling [21]. The results shown in Figure (8) indicated that the values of Zinc concentration in the water of the Tigris River ranged between (0.66-1.29) mg.L^{-1} The lowest value was at the Sharekhan site in the winter, and the highest value was at the Al-Bosif site in the summer. This is due to the waste that the river receives during its flow towards the Al-Bousif site, especially organic materials resulting from household waste, which is the main source of zinc, as well as agricultural waste containing a large amount of High in zinc The water of the Tigris River at the site of Sharekhan and Al-Busif is considered suitable for drinking and irrigation in terms of its zinc concentration and is suitable for watering livestock, horses and poultry. It has exceeded international standards for fish life.



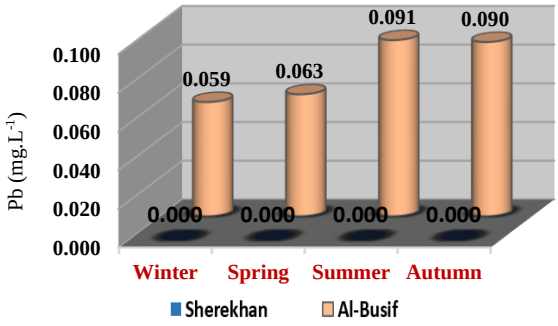
Figures 9. Seasonal average of zinc (mg.L^{-1}) in the Tigris River water

9.lead (Pb)

The results shown in Figure (8) indicated that the values of lead concentration in the water of the river ranged between (0.00-0.091) mg.L-1

The results shown in Figure (8) indicated that the lowest value of lead concentration was at the Sharekhan site in all seasons of the study, and the highest value was at the Al-Bosif site in summer This is because the liquid waste being thrown into the river towards the south of mosul city and high temperature in summer leads to an increase in the concentration of pollutants, as well as a decrease in the river level

Only at the Sharekhan site the water is considered suitable for drinking, for fish life , irrigation, and for watering animals, while the water at the Al-Busif site is considered unsuitable for irrigation and drinking.

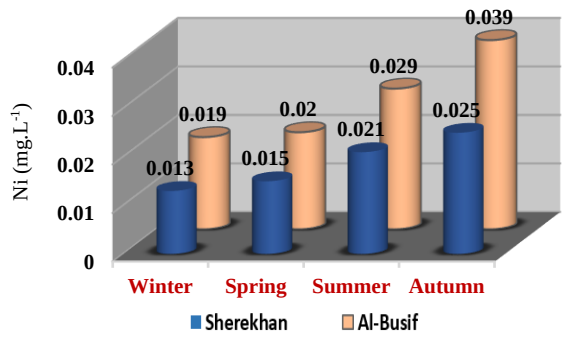


Figures 10. Seasonal average of lead (mg.L^{-1}) in the Tigris River water

10.Nickl (Ni)

The results shown in Figure (9) indicated that the values of nickl concentration in the water of the Tigris River ranged between (0.013-0.039) mg.L^{-1}. The lowest value of nickel concentration was at the Sherikhan site in the winter, and the highest value was at the Bosif site in the autumn, due to the lack of dilution due to the liquid excreta the river receives. Because of the liquid wastes the river receives, the Tigris River is considered the only source of surface water in the city of Mosul, and its water is used for domestic, municipal, industrial, agricultural, and recreational purposes, and it is the final drain for all wastewater resulting from it.

Only the water of the Tigris River at the Sharekhan site is considered suitable for drinking in terms of its nickel concentration. As for the water at the Al-Bosif site, it is not suitable for drinking and causes a risk to human health. Most of it is not suitable for irrigation, and all of it is suitable for watering livestock, poultry, and for fish life, according to international standards.



Figures 11. Seasonal average of Nickl (mg.L^{-1}) in the Tigris River water

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