

Seasonal Variations of Some Ecological Parameters in Tigris River Water at Baghdad Region, Iraq

Adel Mashaan Rabee, Bahaa Malik Abdul-Kareem, Ahmed Saad Al-Dhamin

Department of Biology, College of Science, University of Baghdad, Baghdad, Iraq

E-mail: adelmashaan@yahoo.com, baha782004@yahoo.co.uk

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Abstract

This study aimed at using nine ecological parameters in evaluating the quality of the Tigris River for public usage, by choosing five sampling sites along the river in Baghdad area. These parameters included temperature, pH, the saturated ratio by dissolved oxygen (%sat), biological oxygen demand (BOD₅), nitrate (NO_3^-), phosphate (PO_4^{3-}), fecal coliform (FC) turbidity and total dissolved solids (TDS), and these parameters were used for calculating overall water quality index in the Tigris River at study area. The results showed high values of turbidity and TDS, as well as high count of FC in all study stations, while other studied parameters were within permissible limit defined by world health organization and Iraqi criteria. The results of the overall water quality index indicated that the Tigris River was in class medium, therefore the Tigris River water in study area is relatively not safe for direct domestic use in all seasons.

Keywords: Ecological Parameters, Fecal Ccoliform, Tigris River, Water Pollution

1. Introduction

Water is an essential requirement of human and industrial developments and it is the most delicate part of the environment [1]. "Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties" [2]. "A continuous monitoring of water quality is very essential to determine the state of pollution in our rivers, and water quality index (WQI), in common with many other indices system, relates to a group of water quality parameters to a common scale and combines them into single number in accordance with a chosen method or model of computation"[3-5]. The index presented here is a unit less number ranging from 1 to 100. A higher number is indicative of better water quality.

2. Materials and Methods

2.1. Study Sites

The Tigris River is one of the largest rivers of the Middle East stretching for over 1 900 km, of which 1415 km are within Iraq, with a catchment area of 235000 km², sharing with Euphrates River as the main sources for

man use, especially for drinking water since they pass the major cities in the country [6]. In the present study five sites were chosen on the Tigris River to cover Baghdad area (**Figure 1**), these were, site 1 (Al-Tarmiyah) located north of Baghdad, site 2 (Al-Utafiah) and site 3 (Al-Jadiriah) located middle of Baghdad area, while site 4 (Al-Rasheed) and site 5 (Al-Zafaraniyah) located south of Baghdad.

2.2. Samples Collection and Procedures

Seasonally water samples were collected from selected five sites in Tigris River from February to October 2009, respective in winter (February), spring (May), summer (August) and autumn (October). The samples were collected from just under water surface for analysis of selected parameters included: temperature, pH, the saturated ratio by dissolved oxygen (%sat), biological oxygen demand (BOD₅), nitrate (NO_3^-), phosphate (PO_4^{3-}), fecal coliform (FC), turbidity and total dissolved solids (TDS). Temperature, pH and total dissolved solids were determined in the field with portable Multimeter HANNA Model (HI 9811-5), while other examinations were done according to standard specifications presented by the American public health association [7], except turbidity by using Turbidimeter TN-100.

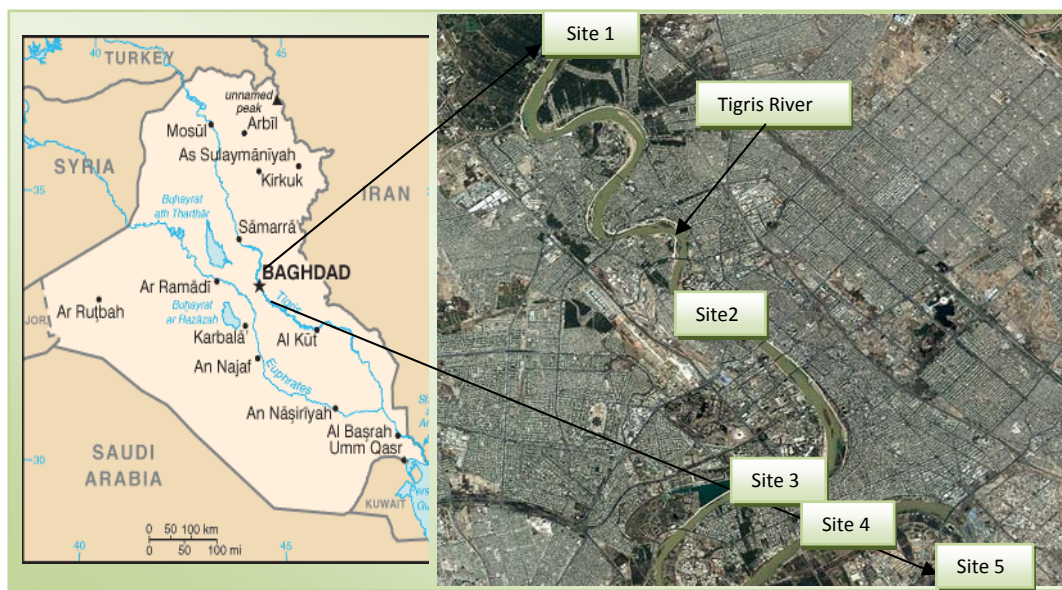


Figure 1. Map of Iraq showing the sample sites on Tigris River.

Table 1. Water quality factors and weights used in this study.

Factor	Weight
Temperature change	0.10
Dissolved oxygen (%sat)	0.17
pH	0.11
Biochemical oxygen demand	0.11
Fecal coliform	0.16
Total phosphate	0.10
Nitrates	0.10
Turbidity	0.08
Total solids	0.07

Table 2. Water quality classification based on WQI value.

Range	Quality
90 - 100	Excellent
70 - 90	Good
50 - 70	Medium
25 - 50	Bad
0 - 25	Very bad

2.3. The Evaluation of Tigris Water

Present study was designed firstly to monitor seasonal variation in water quality parameters in Tigris river and secondly to calculate overall water quality index (WQI) for evaluate Tigris river water in study area by using same studied parameters. The water quality index concept is based on the comparison of the water quality parameters with respective regulatory standards [8].

The development process of a water quality index can be generalized in four steps:

- 1) Selecting the set of water quality variables of concern - parameter selection
- 2) Transformation of the different units and dimensions of water quality variables to a common scale - developing sub-indices.
- 3) Weighing of the water quality variables based on their relative importance to overall water quality - assignment of weights.
- 4) Formulation of overall water quality index-aggregation of sub-indices to produce an overall index [9].

The WQI was calculated by summing up individual quality rating (q_i) and weighing these parameters in total quality evaluation (w_i) as shown in following equation:

$$WQI = \sum_{i=1}^{i=n} q_i w_i$$

where:

q_i = water quality score of parameter i (calculated from special calculator found in Center for Environmental Quality).

w_i = weight factor of parameter i (Table 1).

i and n = number of parameters [9].

The 100 point index can be divided into several ranges corresponding to the general descriptive terms shown in the Table 2.

3. Results and Discussion

3.1. Physico-chemical and Biological Parameters

3.1.1. Temperature

Temperature during the sampling of different seasons was found to vary from 11°C to 26°C (Table 3). The overall

Table 3. The range, average and standard deviation for recorded parameters in studied sites.

Parameters	Sites				
	Al-Tarmiyah	Al-Utafiah	Al-Jadiriah	Al-Rasheed	Al-Zafarania
Temperature (°C)	11 - 24	11 - 24.5	12 - 25.5	12 - 25.5	13 - 26
Dissolved oxygen (%sat)	60 - 115 83.5, ± 24	70 - 110 85, ± 17	72 - 108 83.25, ± 16.9	65 - 98 78, ± 14.5	77 - 100 82, ± 11
Biochemical oxygen demand (mg/L)	1 - 3 1.5, ± 0.9	0.9 - 2 1.3, ± 0.4	1 - 4.1 2.25, ± 1.08	1.5 - 3.5 1.4, ± 0.8	0.9 - 4.4 2.30, ± 1
pH	6.3 - 8.1 7.3, ± 0.5	6.3 - 7.8 7.4, ± 0.5	6.4 - 7.9 7.3, ± 0.5	6.3 - 7.8 7.17, ± 0.5	6.2 - 8.3 7.3, ± 0.6
Fecal coliform (CFU/100 ml)	190 - 1000 439, ± 381	150 - 1400 560, ± 401	250 - 980 400, ± 282	200 - 1500 631, ± 433	210 - 1300 578, ± 420
Total phosphate (mg/L)	0.004 - 0.17 0.066, ± 0.072	0.001 - 0.150 0.043, ± 0.062	0.008 - 0.19 0.051, ± 0.070	0.003 - 0.20 0.067, ± 0.069	0.001 - 0.30 0.076, ± 0.081
Nitrate (mg/L)	0.1 - 3.9 1.75, ± 1.6	0.55 - 3.20 1.60, ± 1.3	0.93 - 2.9 1.90, ± 1.5	1.1 - 3.1 1.77, ± 1.7	0.55 - 2 1.2, ± 1
Turbidity (NTU)	0.2 - 110 31, ± 46	0.51 - 77 25, ± 35	0.40 - 202 56, ± 96	0.5 - 119 33, ± 43	0.84 - 80 20, ± 38
Total dissolved solids (mg/L)	400 - 600 512, ± 87	392 - 553 489, ± 76	350 - 482 450, ± 70	400 - 580 502, ± 80	390 - 723 560, ± 115

Table 4. The overall water quality index for Tigris River in winter.

Environmental parameters	Result field measurement	Sub index value	Weight factor	Weight sub index
Temperature (°C)	12	36	0.10	3.6
Dissolved oxygen (%sat)	82	89	0.17	15.13
Biochemical oxygen demand (mg/L)	2	80	0.11	10.46
pH	7.2	92	0.11	10.12
Fecal coliform (CFU/ 100ml)	1320	21	0.16	3.36
Total phosphate (mg/L)	0.193	92	0.10	9.2
Nitrate (mg/L)	2.5	93	0.10	9.3
Turbidity (NTU)	102	5	0.08	0.4
Total dissolved solids (mg/L)	946	20	0.07	1.4
Overall WQI				62.9

Table 5. The overall water quality index for Tigris River in spring.

Environmental parameters	Result field measurement	Sub index value	Weight factor	Weight sub index
Temperature (°C)	23	18	0.10	1.8
Dissolved oxygen (%sat)	80	87	0.17	14.79
Biochemical oxygen demand (mg/L)	2	80	0.11	8.8
pH	7.7	91	0.11	10.01
Fecal coliform (CFU/ 100ml)	200	37	0.16	5.92
Total phosphate (mg/L)	0.14	94	0.10	9.4
Nitrate (mg/L)	1.7	95	0.10	9.5
Turbidity (NTU)	21	60	0.08	4.8
Total suspended solids (mg/L)	680	20	0.07	1.4
Overall WQI				66.4

Table 6. The overall water quality index for Tigris River in summer.

Environmental parameters	Result field measurement	Sub index value	Weight factor	Weight sub index
Temperature (°C)	26	14	0.10	1.4
Dissolved oxygen (%sat)	73	79	0.17	13.43
Biochemical oxygen demand (mg/L)	4	61	0.11	6.71
pH	8	84	0.11	9.24
Fecal coliform (CFU/100ml)	390	31	0.16	4.96
Total phosphate (mg/L)	0.009	100	0.10	10
Nitrate (mg/L)	1.4	96	0.10	9.6
Turbidity (NTU)	4	88	0.08	7.04
Total dissolved solids (mg/L)	550	20	0.07	1.4
Overall WQI				63.7

Table 7. The overall water quality index for Tigris River in autumn.

Environmental parameters	Result field measurement	Sub index value	Weight factor	Weight sub index
Temperature (°C)	24	17	0.10	1.7
Dissolved oxygen (%sat)	105	98	0.17	16.66
Biochemical oxygen demand (mg/L)	3	67	0.11	7.33
pH	6.4	68	0.11	7.48
Fecal coliform (CFU/100ml)	780	24	0.16	3.84
Total phosphate (mg/L)	0.004	100	0.10	10
Nitrate (mg/L)	0.9	96	0.10	9.6
Turbidity (NTU)	100	5	0.08	0.4
Total suspended solids (mg/L)	492	32	0.07	2.24
Overall WQI				59

range in water temperature was minimum in winter (**Table 4**) and maximum in summer (**Table 6**), seemingly these values followed almost identical seasonal cycles.

3.1.2. pH

The pH of the aquatic systems is an important indicator of the water quality and the extent pollution in the watershed areas [10]. The variations of pH among the seasonal samples of the Tigris River were statistically insignificant at the 5% level. The pH for the water samples varied between 6.2 - 8.3 (**Table 3**) and these values ranged from a minimum average in autumn to a maximum average in summer (**Table 6** and **Table 7**). The generally higher values of the pH could be due to the release of acid-forming substances such as sulphate, phosphate, nitrates, etc. into the water [11]. The pH was relatively lower in autumn, which was the peak of the dry season, when the water level as well as the flow rate was very low. The pH of the water under study in both seasons was within the WHO standard of 6.50 - 8.50.

However, the pH concentration in the study area was within allowable limits for surface water [12].

3.1.3. Saturated Oxygen Ratio

The variations of saturated oxygen ratio (%sat) along the course of the river were statistically significant at the 5% level. These values ranged from a minimum of 73% in summer to a maximum of 105% in winter (**Tables 4, 6**). According to the USDA [13], the level of oxygen depletion depended primarily on the amount of added waste, the size, velocity and turbulence of the stream, the initial DO level in the water and in the stream, and the temperature of the water.

3.1.4. Biochemical Oxygen Demand

Values of biochemical oxygen demand varied between 0.9 - 4.4 mg/L (**Table 3**). The high BOD₅ value in summer (**Table 6**) may be due to discharge of organic wastes (e.g. refuse, human and animal excreta, soap, etc.) into the water, resulting in the uptake of oxygen in the oxidative breakdown of these wastes [11]. It is obvious that

the BOD₅ concentration decreases gradually during the river passage downstream of the river. This phenomenon can be attributed to the natural self-purification of the river and the lack of outfalls along this stretch.

3.1.5. Nitrate

The variations of nitrate among the sampling seasons were statistically significant at the 5% level. Nitrate values fluctuated between 0.1 - 3.9 mg/L in all study sites (**Table 3**), with high average recorded in winter (**Table 4**). The high levels of nitrate recorded in winter might have been because of surface run-off from agricultural activities into the river from the rains. All the nitrate values were within the "no effect" range of 0 mg/L - 6 mg/L for drinking water use [14]. This indicates that no adverse health effects were expected during the sampling months.

3.1.6. Phosphate

The phosphate values obtained is within the tolerable limits. The total phosphate concentrations in study period varied between 0.001 - 0.30 mg/L (**Table 3**), with recorded high values in winter (**Table 4**), which suggest that phosphorus is rarely found in high concentrations in waters as it is actively taken up by plants. High concentrations of phosphates can indicate the presence of pollution and are largely responsible for eutrophic conditions [12]. The phosphate levels increased during winter due to agricultural runoff containing phosphate fertilizers as well as waste water containing detergents.

3.1.7. Fecal Coliform

Fecal coliform have been shown to represent 93% - 99% of coliform bacteria in faeces from humans, poultry, cats, dogs and rodents [14]. Fecal coliform counts ranged from a minimum of 200 CFU/100 ml in spring (**Table 5**) to a maximum of 1 320 CFU/100 ml in winter (**Table 4**). The variations among the sampling seasons were statistically significant at the 5% level. The high counts in winter can be attributed to suitable environmental conditions for bacteria growth in this season [15], and also returned to domestic waste waters and indiscriminate defecation along the river banks by both humans and other animals that graze along the river banks. The major sources of coliform bacteria in this stretch of the Tigris include runoff discharge, agricultural return flow, swimming and animal bathing and excrements [16]. However, the downstream counts in spring were lower than other seasons. This can be attributed to the increased flow rates in that season as most of the tributaries started discharging into the river. The counts of fecal coliform in almost all occasions of sampling indicate significant and increasing risk of infectious diseases

transmission [14].

3.1.8. Turbidity

The variations of turbidity among the sampling months were statistically significant at the 5% level. Turbidity values ranged from a minimum of 4 NTU in summer (**Table 6**) to a maximum of 102 NTU in winter as average (**Table 4**). Winter recorded the highest values, this could be attributed to presence of organic matter pollution, other effluents, run-off with a high suspended matter content and heavy rain fall. The lower values recorded in summer can be that, at that time, all the tributaries had dried up, thus, reducing the influx of suspended matter.

3.1.9. Total Dissolved Solids

Total dissolved solids varied between 350 - 723 mg/L in all study sites, and ranged from a minimum of 462 mg/L in autumn (**Table 7**) to a maximum of 962 mg/L in winter (**Table 4**) as average. The high dissolved solids recorded in winter could be because of domestic effluent discharges and surface run-off from the cultivated fields which might have increased the concentration of ions. The observed high concentration of dissolved solids in the surface water is a pointer to the fact that there are intense anthropogenic activities along the course of the river and run-off with high suspended matter content [17]. The variations of total dissolved solids among the sampling seasons were statistically significant at the 5% level.

3.2. Overall Water Quality Index

Water quality index (WQI) was used to assess water quality relative to the standard for domestic use and to provide insight into the degree to which water quality is affected by human activity [11].

Calculation of overall quality indexes for all seasons is given in **Table 4**, **5**, **6** and **7** respectively. The highest value of WQI for the Tigris River reached to 66.4 in spring (**Table 5**), while the lowest value of WQI reached to 59 was recorded in autumn (**Table 7**). The values of WQI indicates that water quality in the Tigris River was in class Medium (**Table 2**) in all seasons. In general, all of studied sites showed high numbers of fecal coliform, high values of turbidity and presence of dissolved salts and that reflected in the values of their WQI. This could be attributed to improper disposal of wastes, large quantity of agricultural and urban run-off, sewage, over application of inorganic fertilizer, improper operation and maintenance of septic system [12,17]. The previous values of WQI refer to possible decline of environmental properties for Tigris River in study area. A small differ-

ence between values of WQI in different seasons could be attributed to discharge of pollutants to a water resource system from domestic sewers, water discharges, industrial wastes discharges, agricultural runoff and other sources, which can have significant effects of both short term and long term duration on the quality of a river system [18]. However, the ecological parameters and the WQI calculated in this paper give us some idea of the overall pollution of the Tigris River. We can conclude from this that the Tigris River water was slightly polluted in study area, therefore this water is not suitable for direct public usage at all the seasons, in view of the high counts of both fecal coliform and turbidity. Besides, all the other water quality parameters were within the limits set out by the Iraqi [19] and world health organization standards for drinking water. Overall, we need fast measures to avoid further deterioration of the river water quality and we need correct treatment for Tigris water to supply health drinking water for Baghdad population.

4. References

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