APPLICATION OF THE CANADIAN INDEX (CCME WQI) TO ASSESS THE WATER QUALITY OF THE TIGRIS RIVER

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ABSTRACT

This study aims to apply the Canadian Water Quality Index (WQI) to the water of five stations distributed in the Dhuluiya district, southeast of Salah al-Din Governorate, for evaluation for drinking purposes, and samples were collected monthly from each station (from January to December 2020) to estimate each from: the pH value, TDS, BOD, total alkalinity, total hardness, Ca\textsuperscript{2+}, Mg\textsuperscript{2+},\textsuperscript{2+},\textsuperscript{2+} and PO\textsubscript{4}\textsuperscript{3-}. The results of the study reached a high concentration of some measured characteristics, especially solid dissolved salts and calcium ions respectively, which would affect the CCMEWQI values, which ranged between (27.2 - 45.4) and sulfates that amounted to (801.5 mg. Liter\textsuperscript{-1}) and this It indicates that 80% of the studied water samples are of the type of poor water, and the rest are of marginal quality for drinking, and this deterioration in the quality of water reflects the nature of the geological formations that the water passes through, which requires some simple treatments such as freezing and slow melting operations to improve its quality before it is used for drinking.

I. INTRODUCTION

Iraq is characterized by the abundance of fresh surface water represented by the Tigris and Euphrates rivers and their tributaries. The internal waters of Iraq cover an area of 24,000 km\textsuperscript{2}, equivalent to 5% of the country’s area, in the form of various water systems such as streams, rivers, springs and lakes [1]. The Tigris River is the largest river in Iraq and the main source of drinking water for most of its cities, as well as its use for various agricultural and industrial purposes [2]. Despite this, there are not enough reliable studies, data or statistics available worldwide about the Tigris river [3].

The Tigris River is exposed to cases of pollution in some periods as a result of the discarded organic and inorganic pollutants from various sources such as human waste, industrial waste such as sewage, industrial waste, electric power plants, some health institutions such as hospitals, and water. Drains, restaurant wastes and air inputs [4].

Any pollution in the waters of the Tigris River may result in direct pollution of the Euphrates River and related water sources because they are connected to each other by Lake Tharthar [5].

Water is the elixir of life, and thus it regulates the evolution and functions of creation on earth, and, therefore, it is called the mother of all the living world [6,7]. It is thus a natural and basic source, and an important vital element for all living things, especially humans, not only to secure the body's need for the water necessary for them, but to provide the requirements of agriculture, animals, and various industries, and without it, living organisms cannot continue to live.

WQI was initially suggested by [8] and [9]. Since then, researchers have developed several methods of calculating WQI. Some scholars have suggested methods for calculating WQI from such [10,11]. The different water quality index used around the world is the US National Sanitation foundation (NSFWQI) Water Quality Index, the Canadian Environment Ministers Council for the Environmental Water Quality Index (CCMEWQI), the British Columbia Water Quality Index (BCWQI), and the State Water Quality Index. Oregon (OWQI), and the weighted arithmetic of the Water Quality Index (WAWQI) ([12,13,14,15]. generally, two steps are needed to
calculate water quality indices. The first is to convert selected water quality characteristics into sub-index values, second, the aggregation of these values of the water quality index value [11].

II. MATERIALS AND METHODS

Site Description

The study area is located on the Tigris River within Salah al-Din Governorate, which lies between two longitudes (44° 15' - 43° 30') east and two latitude (35° 45' - 35° 5') north. The river crosses about 250 km within the governorate, and the Tigris River is the main resource for surface water in Salah al-Din Governorate, as the river penetrates this city from north to south, and agricultural districts abound on both sides of the river. Since Dhuluiya sub-district is one of the major sub-districts within Salah al-Din Governorate due to its population density and its great need for water, a number of irrigation projects have been established. It is located on the eastern and western banks of the river and is used for drinking, irrigation of agricultural lands and various household uses. The research examined some of the physical and chemical properties of five stations on the Tigris River in the city of Dhuluiya in Salah al-Din Governorate as (shown in Figure 1).

The first station: This station is located northwest of the city of Dhuluiya and in the village of Hardaniyah, which is a rural residential and agricultural area at the same time at longitude (34 34 04 22) degrees north and latitude (14 51 44 08) degrees east. All types of agriculture are spread in this area and are characterized by dense housing. It is adjacent to the Tigris River in a large area of the village, and agricultural land occupies most of its area.

The second station: This station is located northwest of the city of Dhuluiya and in the village of al-Bahariya specifically near the new Al-Bahriya water complex in a rural residential agricultural area at the same time at longitude (93 34 01 31) degrees north and latitude (11 97 44 13 degrees) east and is 4 km away from the station. The first is characterized by the density of dwellings adjacent to the Tigris River in a large area of the village. Agricultural lands occupy the least amount of its area.

The third station: This mostly rural area station is located in the center of the city of Dhuluiya and in the village of Daoudia with (250 m) at longitude (05 43 02 41) degrees north and latitude (31 12 44 14) degrees east and km 3 from the third station. With the density of dwellings adjacent to the Tigris River in a large area of the village, agricultural land is the almost non-existent part of this region.

Fourth station: This station is located southeast of the city of Dhuluiya in a rural mostly agriculture area. The longitude is (01 34 72 32) degrees north and latitude (17 44 40 40) degrees east. In a large area of the village and agricultural land occupies the largest part of its area.

Fifth station: This station is located southeast of Dhuluiya and has the advantage of being agricultural lands devoid of housing adjacent to the Tigris River at longitude (93 33 59 54) degrees north and latitude (38 19 44 16) degrees east, and it is 3.5 km away from the fourth station.
III. MATERIALS AND METHODS:

Water samples were collected seasonally during the period from January 2020 to December 2020 from four sampling stations. Location of the stations was determined by the (https://www.google.com/maps/place).

The sample is taken from the River by 2 liter polyethylene container. The pH of the samples was measured after calibrating the device with buffer solutions with a pH (9, 7, 4). The dissolved oxygen was measured by the modified Winkler method as described in [16], and to measure the vital oxygen requirement, in the same way as dissolved oxygen, the results were expressed in units (mg/liter), and to measure total hardness, the method approved American Society for Testing and Methods (ASTM, 1984)[17] was followed in estimating total hardness by Na₂EDTA method, and the calcium hardness of the samples was determined based on the method of (ASTM, 1984). In water tests, results are expressed in units (mg/L). Magnesium hardness was measured according to the American Society for Testing and Methods (ASTM) method (1984) in units (mg/L), and total alkalinity was measured according to the method described by Welch (1984). The results were in units (mg / L), chloride was measured according to the (ASTM) method (1984) and the result was expressed in units (mg / L), and the active phosphate was measured according to the method published by [18]. For the results in terms of micrograms of phosphorous atom - phosphate per liter., The active silicate concentration was determined for the samples, and the results were expressed in terms of milligrams of silica atom / liter, and nitrite were measured, and the nitrite concentration in the samples was determined, and the results were expressed. In micrograms of nitrogen atom - nitrite / liter Sulfate by the turbidity measurement method, the results are expressed in mg / L [19].

THE CCME WQI[20]

The CCME WQI consists of three measures of variance in the selected water quality objectives (scope, frequency, amplitude). These three measures of variance combine to produce a value between 0 and 100 that represents the overall quality of the water. The CCME WQI values are then converted into rankings using the index categorization schema presented in Table 1

Table 1.-Canadian Water Quality Index (CWQI) ratings, values, and descriptions. Ratings, values, and descriptions as stated in CCME (2005b)

<table>
<thead>
<tr>
<th>Rating</th>
<th>CWQI Values</th>
<th>Interpretive Description</th>
</tr>
</thead>
</table>

Figure (1) (The studied stations map in Al-Dhuliiya city) https://www.google.com/maps/place.
Excellent 95-100 Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.

Good 80-94 Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.

Fair 60-79 Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.

Marginal 45-59 Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

Poor 0-44 Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

This represents the extent of non-compliance with water quality guidelines during the relevant time period.

**Calculation of the CCME WQI**

The detailed formulation of the WQI, as described in the Canadian Water Quality Index 1.0 –Technical Report [20], is as follows

**Scope.** F1 the measure for scope is F1. This represents the extent of water quality guideline non-compliance over the time period of interest.

\[
F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}}\right) \times 100 \quad (1)
\]

**Frequency**, F2 The measure for frequency is F2. This represents the percentage of individual tests that do not meet objectives (“failed tests”).

\[
F_2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}}\right) \times 100 \quad (2)
\]

**Amplitude**, F3 The measure for amplitude is F3. This represents the amount by which failed tests do not meet their objectives. This is calculated in three steps: Step 1- Calculation of Excursion. Excursion is the number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective. When the test value must not exceed the objective.

\[
\text{excursion}_i = \left(\frac{\text{Failed Test Value}_i}{\text{Objective}_i}\right) - 1 \quad (3)
\]

When the test value must not fall below the objective:

\[
\text{excursion}_i = \left(\frac{\text{Objective}_i}{\text{Failed Test Value}_i}\right) - 1 \quad (4)
\]

Step 2- Calculation of Normalized Sum of Excursions. The normalized sum of excursions, nse, is the collective amount by which individual tests are out of compliance. This is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives).

\[
nse = \frac{\sum_{i=1}^{n} \text{excursion}_i}{\text{Number of tests}} \quad (5)
\]

Step 3-Calculation of F3 .

F3 is calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to yield a range from 0 to 100.

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The pH results varied from 7.22 to 9.28 and are mostly within the permissible limits for surface water indicating that the pH is within the alkaline range in nature. The observed alkalinity values were slightly above the WHO recommended level for drinking water. The pH changes affect chemical concentration and the ionic and osmotic balance of aquatic organisms [21]. The pH is a factor that determines the suitability of water for different purposes and the extent of pollution in catchment areas. The pH values in the study environment were within the baseline trend, and this study is consistent with the nature of other Iraqi water environments [22,23].

The alkalinity values are due to the presence of bicarbonate ions [16]. The total alkalinity results varied from 24 to 400 mg/1, which is mostly outside the permissible limits for surface water, indicating that the alkalinity is attributed to bicarbonate when the pH is less than (8.3), where the bicarbonate ion is responsible for the water base because this value is from the exponent. The pH is a turning point for all CO₂ to bicarbonate [24]. We notice through the results that the basal values were high during the spring season, and the reason for this may be that they are affected by rainfalls and floods, as well as the decrease in temperature that increases the percentage of solubility of carbon dioxide and then the increase in the base of water, given that the main sources of carbonate and bicarbonate ion in the water is dissolved carbon dioxide [25].

The results obtained through water surveys conducted in this study showed that the total hardness values ranged between (170-364) mg/liter, which was mostly higher than the minimum permissible limit recommended by the World Health Organization for drinking water [26]. Hardness of water can cause pipelines to become tight and clogged, and scale formation in boilers leading to fuel waste. Hardness also has a serious effect on boiler overheating [27].

Calcium concentrations ranged between (90-264) mg/liter and magnesium ranged between (12-180) mg/liter within the recommended permissible limit of 200 mg/liter for both elements. The results showed the superiority of calcium concentrations over magnesium in all study stations, and this may be attributed to the fact that the interaction of carbon dioxide with calcium is greater and stronger than its interaction with magnesium, and
therefore, larger amounts of calcium are converted into soluble bicarbonate [28]. Calcium may come from living organisms as a result of their decomposition to contain large amounts of calcium that enter their walls or composition [29].

Sulfates are naturally present in surface waters as SO₄²⁻. Industrial discharges and atmospheric precipitation can also add large amounts of sulfate to surface waters. Sulfate concentrations ranged from 0.12 mg / L to 801.5 mg /L which is within the permissible limits of 500 mg /L [30].

The low values of sulfates in the water were recorded during some summer months. They may be due to the decrease in the concentration of dissolved oxygen in the water during this season, which leads to a reduction of sulfates [31]. The levels of sulfate concentrations in the current study did not match the proposed standard specifications for Iraqi drinking water (Central Organization for Standardization and Quality Control, 1996) and global [32,33] of 250 mg / liter.

The high concentration of total dissolved solids (TDS) in surface waters is an indication of intense human activities along the river bed and runoff with a high proportion of suspended matter [34]. Total dissolved solids concentrations ranged from 201 mg / liter to 767 mg / liter, where the permissible limits in drinking water were in the range of 500-1500 mg / liter [26]. Water that contains highly dissolved solids may cause laxative or constipating effects.

Nitrate ion concentrations ranged from 0.17 mg / l to 1.7 mg /l. The nitrate and nitrite ions are natural ions that are part of the nitrogen cycle [35].

Cultivation, dumping of animal waste and leaching of nitrogenous fertilizers can lead to a high concentration of nitrates resulting in increased nutrients in surface waters [26].

The results showed that the lowest value of phosphate in the waters of the Tigris River in the city of Dhuluiya (µg / L0) and the highest value (4.087µg / L). Knowing the specificity of phosphorus is necessary to assess the environmental changes: phosphorus cycle, bioavailability, cycles, carbon and nitrogen [36].

The reason for the increase in phosphate concentration during the warm months can be attributed to the increased use of detergents and washing powders that contain large amounts of phosphates [37]. The high values of phosphorous are mainly due to the disposal of household sewage waste as well as some types of phosphate fertilizers (as The area is agricultural and residential at the same time), which increases the amount of phosphorus because of the phosphate components it carries in its composition [38]. Some of the high levels of phosphorous recorded during the study period were due to the decomposition of the algal groups and phosphate excretion by aquatic organisms [39]. The compound that can benefit from living organisms, especially plants and phytoplankton, and its deficiency determines its productivity is called active phosphate, and it represents the active phosphate (PO₄³⁻) Orthophosphate, which has the advantage of being less soluble in water, [40].

Assessment of water for drinking

The Canadian CCMEWQI model was applied to ten parameters: pH, oxygen biological demand, TDS, total base, total hardness H. T, calcium ions Ca²⁺ and Mg, sulfate SO₄, nitrate NO₃, and phosphates. The index values of each station were classified according to the classification table (1); The results shown in Table (3) All the water of the studies stations were indicated to be for drinking purposes to be poor, and not suitable for drinking and civilian uses, and this deterioration in quality is due to the exceeding of most of the studied standards for the permissible limits according to the Iraqi standard specifications and WHO specifications, especially total hardness, calcium and its causes, sulfate ions Classification of index values for each station based on classification table 1.

The results of the study shown in Table 3 indicate that all the water of the studied stations for drinking and civilian uses is of poor quality (Poor) quality, unfit for drinking and civilian uses, and this deterioration in quality is due to the exceeding of most of the studied standards for the permissible limits according to the standard specifications. Iraq and the specifications of the World Health Organization (WHO), especially total hardness, its causes, calcium ions, sulfate, TDS and PH, and thus the high values of F1, F2, F3, which leads to a decrease in the quality index values that ranged between (27.2 - 45.4). It is noticed from the table that the factor values that increased F1, which represents the percentage of traits in which tests exceed the permissible limits for drinking.
and household uses, as well as the observed increase for the factor F3, which represents deviations adjusted for the percentage of tests exceeding the permissible limits on the total number of tests to reach the value of (99.1) shown in Table 3.

Table 3: WQI values calculated for the Tigris River within the city of Dhuluiya during 2020

<table>
<thead>
<tr>
<th>Station no.</th>
<th>F1</th>
<th>F2</th>
<th>nse</th>
<th>F3</th>
<th>CCME,WQI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>value</td>
<td>classification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>29.16</td>
<td>2.960</td>
<td>74.74</td>
<td>45.4</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>25</td>
<td>3.373</td>
<td>77.13</td>
<td>41.7</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>34.1</td>
<td>114.4</td>
<td>99.1</td>
<td>27.2</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>30.8</td>
<td>3.6548</td>
<td>78.5</td>
<td>40.2</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>34.1</td>
<td>3.24</td>
<td>76.44</td>
<td>43.7</td>
</tr>
</tbody>
</table>

Through this study, I found the CWQI app to be very useful in assessing overall water quality.

The results indicated that the water quality of the Tigris River in general is "very poor" and is not suitable for drinking, which reflects the impact of pollution resulting from household and industrial wastes. This is all as a result of the waste that factories, homes and hospitals receive in the areas through which the river passes before entering the city.

Therefore, the research recommends taking some simple measures, including setting up periodic monitoring on the Tigris River to monitor the discharges that flow into the river, confirming treatment before throwing it directly into the river, in addition to asking the country from which the Tigris originates to maintain the water level coming from it to reduce pollution caused by the slow water flow.

And activating environmental awareness in the civil, agricultural and industrial sectors about the proper use of water. In addition to conducting accurate classification studies of pollutants at the level of existence for their dependence as indicators of water quality.

REFERENCES:

32 CEOH (Committee on Environmental and Occupational Health (Canada). 2003.