ASSESSMENT THE WATER QUALITY FOR TREATMENT PLANTS IN BABYLON GOVERNORATE, USING WATER QUALITY INDEX

Ayah Abedzeed Okab Rana Abd Al-Hadi Mukheef Mohammed Abbas Hussein
Researcher, Al-Qasim Green University Al-Qasim Green University

ABSTRACT
The Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) was applied in the present research on four Water Treatment Plants (WTP) lies along Al-Hilla River in Babylon province (AlTayara WTP (Station 1), Al-hsain WTP (Station 2), Al-Hila AL jaded WTP (Station 3), and Al-Hashimiya WTP (Station 4)), the samples taken from raw water (Al-Hilla River) and treated water. The field work was carried out from January to December 2015. CCME WQI was exercised by using ten physical and chemical water parameters (pH, Calcium, turbidity, Electrical Conductivity, Magnesium, Total Alkalinity, Total Hardness as CaCO₃, Total Dissolved Solids, Chloride, and temperature of the water). Depending on the obtained results from the applied index, Al-Hilla River water quality extended between (71.510-72.883) and can be classified as a moderately polluted water, while the water quality index of treated water was (81.402, 75.317, 81.216, 74.699) for (Station 1, Station 2, Station 3, and Station 4) respectively. The water quality index of treated water of (station 1, and station 3) can be classified as Category II (good), while in other two stations it can be classified as Category III (moderately polluted).

Key words: water quality index, water treatment plants, Al-Hilla River, physical and chemical water parameters.

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1. INTRODUCTION
The surface water quality at any region is decided by natural processes like the rate of precipitation, weathering processes and the erosion of soil as well as the anthropogenic impacts like urban, agricultural activities, and industrial [1].

It is imperative to prohibit and control the pollution of river and to have effective information on the water quality for management. Many efforts were aimed to making
quantitative and qualitative decisions depending on monitoring the quality of water data and the results explaining[2]. One sure way by which information on the water quality could be conveyed to those concerned is by using suitable indices [3]. It represents simple and easy way for estimation and studying the status of any water body. The water quality index includes mathematical equation deal with huge numbers of the quality of water data and transforms it into single number.

There are many methods used to determine the water quality index (Weighted Arithmetic Index (WAI), Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI), Bhargava method, etc.), [4]. In this research Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) had been applied.

Al-Hilla River, a branch from the Euphrates River, is the only water source for all water treatment plants in Babylon province, this source suffering decrease in its quantity (mean annual flow decreased from (30) BCM to (25) BCM according to data records over the last (70) years due to the building of enormous water engineering structures in upstream Syria and Turkey, the Euphrates flow regime has transferred towards less declared seasonal variation. In addition to, the Euphrates river water quality has become a serious issue as a result to the return of flows from agricultural drainage that because the problems of salinity that are increased along the course of river, also dumping of untreated sewage into the Euphrates and its tributaries contributes too their forms of the pollution of water [5].

This research focus on measuring the water parameters of Al-Hilla River in Babylon government and four water treatment plants in Babylon province, so the river and the WTPs quality shall be determine by using CCME water quality index.

2. DESCRIPTION OF STUDY AREA
The Euphrates, is the longest river in Western Asia with a total length of (2,786) km², creates in Turkey, flows out of Syria and combines the Tigris in Iraq to form the Shatt al Arab which drainage into the Persian Gulf. The Euphrates Basin covers about (440,000) km², (47)% of which is located in Iraq[12]. Al-Hilla River is a branch river divided from the Euphrates. Four water treatment plants located along Al-Hilla River in Babylon province (Station 1, Station 2, Station 3, and Station 4). As shown in fig. (1).

Figure 1 The water treatment plants stations along Al-Hilla River.
3. FIELD WORK
In present research, two water samples, raw and treated water are collected from each water treatment plant. Raw water samples have been taken from Al-Hilla River at the intake structure as well as treated water samples have been taken from the outlet after water passing through the treatment. The samples were gathered during (2015)(three samples in each month). The samples were gathered by using plastic bottles of (1) liter after the water washed the outside of the processing unit three or more times before bottling sample as mentioned in the standard methods for examination water and wastewater [6].

4. LABORATORY WORK
In order to compute the Water Quality Index, the levels of some physical and chemical water quality parameters in the four water treatment plants, were measured and then analyzed for the parameters (pH, Calcium (Ca$^{+2}$) mg/l, turbidity (Nephelometric Turbidity Unit), Electrical Conductivity (EC)μs/cm, Magnesium (Mg$^{+2}$) mg/l, Total Alkalinity (TA) mg/l, Total Hardness (TH) mg/l (as CaCO$_3$), Total Dissolved Solids (TDS) mg/l, Chloride (Cl$^{-}$) mg/l, and temperature of the water (°C), accordance to standard methods for the examination of water and wastewater[6].The tests of temperature, turbidity, TDS and pH were measured on site at the position of sampling and the other tests were done in the laboratory. In this research Iraqi standards for drinking water have been used Table (1) [7].

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Iraqi Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>---</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>25</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>mg/L</td>
<td>200</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>5</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>1000</td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>μs/cm</td>
<td>2000</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>mg/L</td>
<td>500</td>
</tr>
<tr>
<td>Calcium</td>
<td>mg/L</td>
<td>150</td>
</tr>
<tr>
<td>Magnesium</td>
<td>mg/L</td>
<td>100</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>350</td>
</tr>
</tbody>
</table>

5. DETERMINATION OF WATER QUALITY INDEX
The water quality index of the Canadian model (CCME WQI) that described by Canadian Council of Ministers of the Environment, (2001)[8] was used in this research. This model calculating the final figure crossing on the status of water quality by using the three mathematical factors, the scope, frequency and amplitude, where these factors are calculated from the specific to each variable equations, where the final obtained number detect the state of water quality, as follows:

The First Factor F1 (Scope)
Mean the ratio between the number of variables that do not match their values with the objectives set for the model (Objective) and the total number of variables and is calculated from the equation (1) below:

$$F1 = \frac{Number\ of\ failed\ variables}{Total\ number\ of\ variables} \times 100 \quad (1)$$
The Second Factor F2 (Frequency)
Represents the ratio between the number of tests that did not meet the objectives set for the model and the total number of tests values. Calculated from the equation (2) below:

\[
F2 = \frac{\text{Number of failed tests}}{\text{Total number of tests}} \times 100
\]  

(2)

The Third Factor (F3) (Amplitude)
Represents the failed tests and which do not correspond with the objectives and values of the tests are calculated according to the following items:
(a) The number of times that an individual concentration is maximal than (or less than, when the objective is a minimum) the objective is termed an “excursion” and is expressed as follows in eq. (3). When the test value must not exceed the objective:

\[
\text{excursion}_i = \frac{\text{failed test value}_i}{\text{objective}_i} - 1
\]

In the cases when the value of the test should not fall below the objective, can be expressed as in equation (4).

\[
\text{excursion}_i = \frac{\text{objective}_i}{\text{failed test value}_i} - 1
\]

(4)

(b) The collective amount by which individual experiments are out of compliance can be calculated by summing the excursions of individual experiments from their objectives and then dividing by the total number of experiments (both those meeting objectives and those not meeting objectives). This variable, referred to as the normalized sum of excursions, or nse, is calculated as in equation (5).

\[
nse = \frac{1}{\text{No.of tests}} \sum_{i=1}^{n} \text{excursion}_i
\]

(5)

(c) F3 can be calculated by an asymptotic function that scales the normalized sum of the excursions from objectives (nse) to yield a range from 0 to 100, and can be calculated from the equation (6) below:

\[
F3 = \frac{nse}{0.01 + nse + 0.01}
\]

(6)

From the obtained factors, the index can be calculated by summing these three factors as if they were vectors. The summation of the squares of each factor is equal to the index square. This approach treats the index as a three-dimensional space defined by each factor along one axis. In this model, the index changes in direct proportion to changes in all three factors, then the WQI can be calculated by eq. (7) below:

\[
CCME\ WQI = 100 - \frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732}
\]

(7)

The values of water quality index that products must be ranging from (0 – 100), and these values are express about water quality according to Table (2).

<table>
<thead>
<tr>
<th>Water Treatment Required</th>
<th>Quality</th>
<th>Range</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>sterilization only</td>
<td>Excellent</td>
<td>95-100</td>
<td>I</td>
</tr>
<tr>
<td>Simple Treatment</td>
<td>Good</td>
<td>80-94</td>
<td>II</td>
</tr>
<tr>
<td>Conventional treatment</td>
<td>Moderate</td>
<td>65-79</td>
<td>III</td>
</tr>
<tr>
<td>Advanced treatment</td>
<td>Bad</td>
<td>45-64</td>
<td>IV</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>Very bad</td>
<td>0-44</td>
<td>V</td>
</tr>
</tbody>
</table>

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editor@iaeme.com
6. RESULTS AND DISCUSSION

Firstly, The former equations of the CCME WQI have been applied on the results of monthly average data of water analysis of Al-Hilla river and four water treatment plants that had been taken during (2015) and Table(3) shows the three measures of variance, F1 (scope), F2 (frequency) and F3 (amplitude).

Table 3 The calculated values of CCME-WQI

<table>
<thead>
<tr>
<th>Term of the Index</th>
<th>Values for raw water</th>
<th>Values for treated water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>St.1</td>
<td>St.2</td>
</tr>
<tr>
<td>Scope, F1</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Frequency, F2</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>Excursion</td>
<td>15.473</td>
<td>22.620</td>
</tr>
<tr>
<td>nse</td>
<td>0.129</td>
<td>0.189</td>
</tr>
<tr>
<td>CCME-WQI</td>
<td>72.694</td>
<td>71.965</td>
</tr>
</tbody>
</table>

- Monthly WQI for all samples have been plotted in Fig. (2), the figure show that the quality of raw water for all water treatment plant stations are moderately polluted "category III", while for treated water the quality is good "category I" in stations 1 and 3. In other two stations (2, 4) the water quality remain moderately polluted "category III". In raw water this moderately polluted quality may be due to the pollutants discharge from domestic sewers to a water resource system, discharges of industrial wastes, discharges of storm water, agricultural runoff and other pollutant sources, all of these pollutant sources may be untreated, can cause significant impacts on both short term and long term duration on the river system quality [9].

- The results of turbidity varied from (3.4-25.9)NTU in raw water and from (0.4-10.4)NTU in treated water for all stations as shown in Fig. (3, 4), some of these values were meeting the Iraqi standards while the other was higher than the recommended permissible level. The presence of turbidity in water is caused by suspended particles like clay, finely divided organic matter, silt, plankton and other microscopic organisms [10].

- In aquatic systems, the temperature is important as it can cause mortality and it can be influenced on the solubility of some materials in the column of water. Temperature affects the chemical reactions speed, in the rate when algae and aquatic plants photosynthesize, the metabolic rate of another organism, and how pollutants, parasites, and another pathogens interact with aquatic residents. In this study temperature show great fluctuation as shown in Fig. (5, 6) which return to fluctuate naturally both daily and seasonally[11]. Thermal pollution have directly impacts, like the discharge of the cooling water of industries into aquatic receiving bodies, or indirectly through the activities of human like the removal of shading stream bank vegetation or the construction of impoundments [12].

- The pH is important for any aquatic ecosystem as it is closely connected to biological productivity. pH values from 6.5 to 8.5 usually indicate good water quality and this range is ideal of most drainage basins of the world [13]. PH values in current study for all stations in all months were within Iraqi standards as shown in Fig. (7, 8).

- The alkalinity values in this study were meeting the permissible level of Iraqi standards as shown in Fig. (9, 10). The normal behavior of the natural water alkalinity is connected with bicarbonate, carbon dioxide, hydroxide components and carbonate. These elements are characteristic of the water source and the natural processes occur at any given period of time. For domestic and particular industrial usage, these characteristic are often minimized by treatments like neutralization, aeration, softening, etc.[10].
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- Values of TDS recorded concentrations varied between (832- 1123) mg/l for raw water and (751- 1138) mg/l for treated water in all study stations as shown in Fig. (11, 12). Some of the results of total dissolved solids exceeded the permissible limits of (1000)mg/L Iraqi standard. If the total dissolved solids values less than(1000)mg/l the water is known as fresh water and if it more than(1000) mg/l the water is known as brackish water[14].

- During study; total hardness was ranged from (418- 559) mg/l in raw water and between (400-552) mg/l in treated water as shown in Fig. (13, 14). Total hardness considered indicator of hydrogeology and aesthetic quality of water [15, 16]. In general, high total dissolved solids(TDS) and high total hardness can cause taste problems. The higher TDS of subsurface drainage water may lead to high treatment costs because of the increased the hardness of water.

- Magnesium values varied from (39- 59) mg/l in raw water and between (37- 63) mg/l in treated water as shown in Fig. (15, 16). Magnesium causes hardness in water. As well as, the higher levels of Magnesium affect human health caused Encephalitis [14]. Magnesium results show that the maximum values were within the Iraqi specifications limits.

- The result of Calcium was between (85- 137) mg/l in raw water and between (83- 137) mg/l in treated water as shown in Fig. (17, 18). There is no difference in Calcium concentration between the raw and treated water because the water treatment plants are conventional. These results illustrate that all Calcium values were within Iraqi standards. The Calcium enters a water supply by leaching from minerals within an aquifer. Common calcium-containing minerals are calcite and gypsum, also some human activities involved with increase calcium by increasing concentration of carbon dioxide which form the carbonic acid that eventually lead to dissolve the bituminous rocks[17-19].

- Electrical Conductivity values in the stations of the present study ranged between (1272-1717) µS/cm in raw water and between (1251-1721) µS/cm in treated water. The permissible limits for all samples during the study period matches standard specifications for Iraqi drinking water standards (2000 µS/cm). Fig. (19, 20) show the variation of the electrical conductivity during the period of the study.

- Chloride concentration values during study period were between (116-208mg/l) in raw water and between (112-206 mg/l) in treated water as shown in Fig. (21, 22). All values of chloride concentration were within Iraqi standards.

Figure 2 Show the water quality index for all WTP stations.
Figure 3 Turbidity values for all WTP stations.

Figure 4 Turbidity values for all WTP stations.

Figure 5 Temperature values for all WTP stations
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**Figure 6** Temperature values for all WTP stations

**Figure 7** pH values for all WTP stations.

**Figure 8** pH values for all WTP stations

**Figure 9** Alkalinity values for all WTP stations
Figure 10 Alkalinity values for all WTP stations

Figure 11 Total dissolved solids values for all WTP stations

Figure 12 Total dissolved solids values for all WTP stations

Figure 13 Total hardness values for all WTP stations
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**Figure 14** Total hardness values for all WTP stations

**Figure 15** Magnesium values for all WTP stations

**Figure 16** Magnesium values for all WTP stations

**Figure 17** Calcium values for all WTP stations
Figure 18 Calcium values for all WTP stations

Figure 19 EC values for all WTP stations

Figure 20 EC values for all WTP stations

Figure 21 Chloride values for all WTP stations
7. CONCLUSIONS

- According to the field works of the research, some treated water parameters met the Iraqi standards like (pH, Alkalinity, magnesium, calcium, and chloride) while the other were exceeded Iraqi standards.

- From field measurements, the research show that the water treatment plants were efficient in removal of turbidity, but for the chemical parameters there were no different between the inlet and outlet water concentrations standards and the reason is referred to the absence of any water chemical removal units in the studied water treatment plants.

- The monthly average WQI values for period January – December 2015 were found to be classified as "Moderately polluted" for Al-Hilla River at WTPs intakes and ranged from "Good" to "Moderately polluted" for treated water at WTPs outlet.

- From the WQI results, AlTayara WTP (Station 1) was more efficient from the other stations.

REFERENCES


