Study and analysis of Euphrates river water quality in Al-Kufa Station

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Abstract
Water quality managers are concerned with controlling pollution from human activity so as to ensure that the water is suitable for its intended uses. Water quality management is also the science of knowing how much waste is too much for a particular water body. To know how much waste can be tolerated (the technical term is assimilated) by a water body, therefore, quantitative measurements of pollutants are obviously necessary before water pollution can be controlled.

Importance of present study through maintaining of clean water is accommodate with sustainable development that meets the needs of the present without compromising the ability of the future generations to meet their own needs.

Euphrates River, the basis of life survival in Iraq and its supplier to many activities (drinking, swimming, industry, agriculture, etc...), therefore, the cleanest available this source in Iraq should be protected.

Euphrates river passes a number of large cities with rural areas and receives various types of waste that may affect the quality of its water and therefore the living organisms in it. Data for Euphrates river in Al Kufa station were collected, from the period extended from January to December 2008. These data represent the Phosphate (PO$_4$), Nitrate (NO$_3$), Monthly Rain Totals(Ra), Hydrogen Ion concentration (pH), turbidity unit (T.U.), Chloride (Cl), precipitated dust particles (PM), Ambient Temperature (T), and Monthly Percent of Sand Storm occur (S.ST) as independent variables, Biological Oxygen Demand (BOD), as dependent variable. The statistical models are described the relations between parameters of water quality. The regression analysis was done by using "Data Fit" program version 9.0 software.

It was noticed that nitrates has highest negative correlation with precipitated dust particles may be precipitated directly to the river or indirectly, while it has a moderate negative correlation with pH.

Feasible positive correlation between turbidity and temperature was found, and moderate positive relation between monthly rain totals and sand storm was noted.

The study shows the optimum correlation equation as regression model form with coefficient of determination $R^2$ equal to 0.999.

This study also showed that the discharging domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water from adjacent areas causing some contaminants increased in Kufa river water.
Finally, phosphates, nitrates, and pH values measured agreed well with the Iraqi river water standards, exempt turbidity, chloride, and BOD a result of some pollution sources in area during the period of the study.

**Key word:** water quality, BOD, domestic water, regression models, correlation factor.

**Introduction**

As the Earth’s population continues to increase rapidly, the growing human need for freshwater (e.g. for drinking, cooking, washing, carrying wastes, cooling machines, irrigating crops, receiving sewage and agricultural runoff, recreation, and industrial purposes) is leading to a global water resources crisis (Harrison, 1999).

Water is found naturally in many different forms. In the liquid state it is found in rivers, lakes and groundwater (water held in rock formations), and also as sea water and rain. As a solid, it is found as ice and snow. Water in the vapour state is found in the atmosphere. You will certainly be familiar with the fact that sea water contains large quantities of dissolved material in the form of inorganic salts but it may come as a surprise that nowhere in the environment can you consider water to be chemically pure. Even the purest snow contains components other than water.

Pollutants are often materials which are naturally present in the environment, with their adverse effects being caused by concentrations higher than those which would be expected from natural causes (Reeve, 2002).

A water quality monitoring system would take data readings and determine possible causes of poor water quality, aid in the location of pollution sources, and suggest remedial actions to improve water quality (Jain and Singh, 2003).

Water quality is usually determined by the water source, the treatment it receives and its method of distribution. Standards of water quality take into consideration the physical, chemical, and microbiological characteristics, the radioactivity, and compliance with the *Public Health Service Drinking Water Standards* 1962 (Pfafflin and Ziegler, 2006). Water quality standards are an additional control to protect water bodies. Generally, water quality standards focus on the receiving water’s ability to integrate, dilute, or absorb pollutants. A facility may have to install controls beyond those required to achieve technology-based standards to meet water quality standards (Liu, 1999).

Many studies were carried out for different rivers in the world in different forms. In Iraq, Euphrates river has a large importance for Iraqi environment researchers because of the detrimental effect of pollutants resulting from treated and untreated domestic wastewater, treated and untreated industrial wastewater and farming and agricultural pollutants discharged.

**Importance of study:**

- Water is a vital ingredient of everyday life, it is therefore important that we understand more about the causes of water contamination and methods of purifying polluted rivers.
- Monitoring pollutants in water has become a global concern due to the limited and diminishing water resources and the negative impact of pollutants on fresh water sources.
- The Euphrates River, the basis of life survival in Iraq and its supplier to many activities (drinking, swimming, industry, agriculture, etc...), therefore, the cleanest
available sources of groundwater and surface water in Iraq should be protected, used, and maintained for potable water supply purposes via water quality analysis.

-Due to lack of studies and the absence of a monitoring and assessment of water resources (surface and ground water) in the Ministry of Water Resources or any organization in Iraq, turned to the research, which is covers the study and analysis of monthly water quality parameters in order to add it as data base of Iraq water resources.

-Maintaining of clean water accommodate with sustainable development that meets the needs of the present without compromising the ability of the future generations to meet their own needs

The objectives of the study are:

1) To characterize the water quality of Shatt Al Kufa station
2) To identify the effects of various types of pollutants discharged by different sources on river.
3) To obtain quantitative information on the physical, chemical, and biological characteristics of water via statistical sampling

Study area

The length of the Euphrates River 2775 km and its branches after Al-Kifil town directly about (1Km) to two branches (first one is Shatt Al Kufa and another a branch named Al Abbasia river). The main source of water for this river are rain water, stored water as lake and reservoirs.

Al Kufa station is located on the Euphrates river/Shatt al-Kufa, near the Al Kufa water treatment plant for surface water monitoring, at coordinates (E044.4075, N32.03941). The water level at the station is not stable at a certain depth, according to the season of the year, in the summer decline is attributed to its lowest level so that you can see the bottom of the river in some areas near the station, and even in winter the water levels are not rising required, and the center of the river is not covered with water even in winter and the rainy season (figure 1).

The nature of the land surrounding the station is agricultural land, with some residential buildings at a distance (100 m to the south) and farming land on the other side.

Al Kufa river passes through many towns and villages thus it represents the main source for different uses such as:

i. Water supply systems: The river represents the supply source for many water treatment plants such as Al-Najaf and Al-Kufa water treatment plants.

ii. Irrigation: The river is the main source of the irrigation for large agricultural areas locating on both sides of the river.

iii. Industrial purposes: The river represents the main source for all industrial activities in the area.

In addition to these main uses, the river receives many pollutants discharged by different sources, including:

i. Municipal wastes: Municipal wastes are discharged from Northern drainage of Al Kufa (2 km / north) and raw waste water discharged from Al Jimaah zone at 1 km / north of station.
ii. Agriculture wastes: Such as Pesticides which result primarily from surface runoff from agricultural lands.

iii. Industrial wastes: water usage for product processing within industries discharging liquid effluents into municipal sewerage systems; and infiltration/inflow and/or stormwater runoff, such as soft drink factory and many private industries.

Fig. 1: Map of the studying area in the national context.

Model Formation
A large number of variables are associated with water quality information, the measurement frequency depends on the changes in the variable as well as its use. The major groups of water quality variables are organic matter, major and minor ions, toxic metals, nutrients and sediment data. The biochemical oxygen demand, chemical oxygen demand and dissolved oxygen are indicators of the presence of organic matter in water. The nutrients, such as phosphorus and potassium, are important from the point of view of water resources (Jain, S. K., and Singh, V. P., 2003).

Data of water quality of the Euphrates river (at Kufa river station) are being analyzed monthly (two samples per month), and the average pollution levels are being determined.
In present study the statistical models are described the relations between parameters of water quality. The regression analysis was done by using "Data Fit" program version 9.0 software.

Accordingly, multiple non-linear regression models in three forms were used for each design requirements to choose which form gives the best fitting of data. The regression models that were proposed and investigated can be seen in table (1).

Table (1): The proposed models.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Equation Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>( y = \exp(ax_1 + bx_2 + \ldots + j_k x_k + M) )</td>
</tr>
<tr>
<td>B</td>
<td>( y = ax_1 + bx_2 + \ldots + j_k x_k + M )</td>
</tr>
<tr>
<td>C</td>
<td>( y = a x_1 + b x_2 + \ldots + j_k x_k )</td>
</tr>
</tbody>
</table>

Where;

- \( y \) = dependent variables.
- \( x_1, x_2, \ldots, x_k \) = the independent variables.
- \( a, b, c, \ldots j_k \) = are model coefficients,
- and \( M \) = model constant term.

**Data Analysis**

Data for Euphrates river in Al Kufa station were collected, from the period extended from January to December 2008. These data represent the Phosphate (PO_4), Nitrate (NO_3), Monthly Rain Totals(Ra), Hydrogen Ion concentration (pH), turbidity unit (T.U.), Chloride (Cl), precipitated dust particles (PM), Ambient Temperature (T), and Monthly Percent of Sand Storm occur (S.ST) as independent variables, Biological Oxygen Demand (BOD), as dependent variable, as shown in table (2).

Table (3) shows the data statistics and correlation matrix of water quality parameter used in present study.

The optimum correlation equation from rank A in an exponential form with coefficient of determination \( R^2 \) equal to 0.999, was shown in table (4).

Fig (2) and (3) shows the plot model and residual error for regression model obtained in Euphrates river at Al Kufa station respectively.
Table (2): Description of independent and dependent variables in Al Kufa river station.

<table>
<thead>
<tr>
<th>Type of variables</th>
<th>Variables</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent</strong></td>
<td>X&lt;sub&gt;1&lt;/sub&gt;</td>
<td>Phosphate (PO&lt;sub&gt;4&lt;/sub&gt;, mg/L)</td>
</tr>
<tr>
<td></td>
<td>X&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Nitrate (NO&lt;sub&gt;3&lt;/sub&gt;, mg/L)</td>
</tr>
<tr>
<td></td>
<td>X&lt;sub&gt;3&lt;/sub&gt;</td>
<td>Monthly Rain Totals (Ra, mm)</td>
</tr>
<tr>
<td></td>
<td>X&lt;sub&gt;4&lt;/sub&gt;</td>
<td>Hydrogen Ion Concentration (pH)</td>
</tr>
<tr>
<td></td>
<td>X&lt;sub&gt;5&lt;/sub&gt;</td>
<td>Turbidity unit (T.U., NTU)</td>
</tr>
<tr>
<td></td>
<td>X&lt;sub&gt;6&lt;/sub&gt;</td>
<td>Chloride (Cl, mg/L)</td>
</tr>
<tr>
<td></td>
<td>X&lt;sub&gt;7&lt;/sub&gt;</td>
<td>Precipitated dust particles(PM, g/m&lt;sup&gt;2&lt;/sup&gt;/month)</td>
</tr>
<tr>
<td></td>
<td>X&lt;sub&gt;8&lt;/sub&gt;</td>
<td>Ambient Temperature ( T, ºC )</td>
</tr>
<tr>
<td></td>
<td>X&lt;sub&gt;9&lt;/sub&gt;</td>
<td>Monthly Percent of Sand Storm occur (S.ST., %)</td>
</tr>
<tr>
<td><strong>Dependent</strong></td>
<td>Y</td>
<td>Biological Oxygen Demand (BOD, mg/l)</td>
</tr>
</tbody>
</table>

**Results and discussion**

From table (3) BOD in station has poor negative relation with monthly rain totals, precipitated dust particles and sand storm occur, this mean BOD has a best correlation with rain and particulates components compared with other variables.

BOD is the amount of oxygen required for the biological decomposition of the organic matter under aerobic conditions (Duggal, 2008), so this correlation may be indicates the indirect effects of wet and moist precipitated particulates on water river. Nitrates indicate the presence of fully oxidized organic matter (Punmia and Jain, 1998), major sources of nitrogen components include municipal wastewater discharges, runoff from animal feedlots, chemical fertilizers, and nitrogen-decomposition from the atmosphere (Masters and Ela, 2008). Phosphate(PO<sub>4</sub>) is one of phosphorus compounds, in organic form. It released during anaerobic decomposition are very soluble in water and do not bind to metal ions or sediments. Soluble phosphate is easily taken up by plants and used as a nutrient (Weiner and Matthews, 2003), NO<sub>3</sub> has moderate positive correlation with PO<sub>4</sub> and ambient temperature, apparently as a result of nutrients found in domestic sewage that discharged to Al Kufa river from Northern drainage of Al Kufa (2 km/north) and raw waste water discharged from Al Jimaah zone at 1 km / north of station. Nitrates has highest negative correlation with precipitated dust particles may be precipitated directly to the river or indirectly, such as with rain that falls on land is drained through the sewage system eventually make their way into river (dust particles may be coated with chemical fertilizers from adjacent agricultural lands, and nitrogen-decomposition from the atmosphere), while it has a moderate negative correlation with pH.
Also, table (3) shows moderate positive relation between monthly rain totals and sand storm and with pH, and moderate negative relation with temperature and BOD.

pH is a measure of the concentration of free hydrogen ion in water. Water, and other chemicals in solution therein, will ionize to a greater or lesser degree (Steel, and McGhee, 1979), and the pH value of neutral (pure) water is 7.0 and when it is less than 7it is acidic in nature while above 7 is alkaline in nature (Lal, 2009). From table(3) the correlation between pH and chloride is positive and moderate, while it has negative moderate relation.

Feasible positive correlation between turbidity and temperature was found, and negative correlation with chloride, this because the turbidity means presence of suspended material such as clay, silt, finely divided organic material, plankton, and particulate material in water (Davis and Cornwell, 2008), it also, a measure of cloudiness (Kiely, 1997) with measuring unit expressed in term NTU (nephelometric turbidity unit) (Nathanson, 2000).

Chlorides in natural water result from the leaching of chloride-containing rocks and soils with which the water comes in contact, in addition, agricultural, industrial, and domestic waste waters discharged to surface waters are a source of chlorides (Metcalf and Eddy, 2004). Analysis in present study shows positive moderate correlation between chloride and precipitated dust particles as a result of industrial particles composition in area and river.

Some chemical substances exist as dry particles in the air while others enter water body as wet particles such as rain, snow, sleet, hail dew or fog (Meenambal et. al., 2005). Particles may be precipitated directly to the river or indirectly, such as with rain that falls on land is drained through the sewage system eventually make their way into river. The introduction of these acids and chemicals into river causes a sudden drastic change in the pH value.

Table (5) shows the allowable limits of water quality parameters in river water body and drinking water according to IRAQI, WHO, US EPA, and CANADIAN standard. Most values measured agreed well with the Iraqi river water standards given in table 5, exempt turbidity and chloride, this incremental in concentration because of particulates that add turbidity to water by many causes as silt, clay, organic matter, algae and other microorganisms, and any other particulate matter that can scatter or absorb light. Also, increasing in chlorides concentration was found. Hence, chlorides when exceeded, indicate the presence of sewage, agricultural, or industrial pollution in river.

Fig. (4-6) shows the variation of phosphates, nitrates, and pH levels in the river water during the period of the study. All values measured are below the allowable Iraqi limits for rivers, less than 3 mg/l, 50 mg/l and ranged(6.5-8.5) respectively (values detailed in table 5).

Fig. (7-9) shows the variation of turbidity, chlorides, and BOD levels in the river water during the period of the study. Some of values measured are higher than allowable Iraqi limits for rivers, as a result of contamination sources mentioned above.
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Figure (2): Plot model of water in AL Kufa station

Figure (3): Residual Error For Regression Model Obtained In Euphrates River At Al Kufa Station
Table (5): Allowable limits of water quality parameters in river water body and standards

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>None</td>
<td>&lt; 5</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>PO₄</td>
<td>mg/L</td>
<td>………</td>
<td>&lt; 3</td>
<td>………</td>
<td>………</td>
<td>………</td>
</tr>
<tr>
<td>NO₃</td>
<td>mg/L</td>
<td>0 - 40</td>
<td>50</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>pH</td>
<td>Hydrogen Ion conc.</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>TU</td>
<td>NTU</td>
<td>&lt; 10</td>
<td>10-18</td>
<td>5-25</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cl</td>
<td>mg/L</td>
<td>200</td>
<td>200</td>
<td>250-600</td>
<td>250</td>
<td>&lt; 250</td>
</tr>
</tbody>
</table>

* Source: Iraqi environmental legislations book

** Source: (Liu , 1999)
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Figure (4): Variations of Phosphates with Time

Figure (5): Variations of Nitrates with Time
Figure (6): Variations of Hydrogen Ion Concentration (pH) with Time

Figure (7): Variations of Turbidity with Time
Figure (8): Variations of Chloride with Time

Figure (9): Variations of BOD with Time
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References


