The Case of Water Inflows of the Tigres and Euphrates Rivers
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Abstract

Iraq is located in the arid and semi-arid regions of the world. Therefore the rate of annual rainfall is very low, especially in the southwestern area (less than 80 mm), while in the north and north-east areas the rainfall may reach in some areas to 1000 mm. Thus, Iraq water sources depending, particularly on surface water inflows of the Tigris and Euphrates rivers and their tributaries.

This study consider the shortage which happened in water inflows of the Tigris and Euphrates rivers due to the construction of reservoirs on tributaries of both river basins in Turkey and Syria, as well as the impact of climate change, including rising temperatures above rates and attributed the cause of rising temperatures due to an increase in the number of sunspots occurring in recent years, on an ongoing basis in addition to warming (due to many factors, including the large amount of carbon dioxide emitted in the atmosphere), the period of the wave length duration of sunspots was estimated to be between 9 to 14 years on average around 11 years.

Water inflows for the Tigris and Euphrates rivers have been calculated for ten years moving averages for the period from 1933 until 2012, Continuous decrease In the 10 years average annual inflows for Tigres and Euphrates rivers where observed particularly from year 1970. (The commencing of reservoir construction on Euphrates river). The natural Inflows of Euphrates river was 29.8 Mds. Cubic meters for the period, (1933 to 1970) and it is 16.53 Mds. for the period (2002-2012). It is expected to continue to this decline in the coming years due to climatic changes besides the continuation of reservoirs construction on tributaries of the Tigris and Euphrates rivers basins in the neighboring countries, in addition to the absence of agreements with them so far for the purpose allocating the right of each country from the rivers inflows.

-Introduction
Water inflows in Iraq are linked to the amount of rain and snow that falls in the major basins of the rivers, (Tigres and Euphrates and their tributaries) as well as the policy of operation of the dams and the reservoirs built in the upper common rivers in Turkey, Syria and Iran. There is no international convention for water allocation between Iraq and these countries so far. Expansion project development for irrigation and reservoir construction in neighboring countries have already caused significant changes in the flow regime of Euphrates River and to a lesser extent to the Tigris River, both in terms of quality and quantity. The implementation of the projects in the neighboring countries caused a severe reduction in Euphrates flow, which increased the salinity in the lower reaches of the river, in which it seriously affecting agriculture and would have major adverse consequences for large numbers of people living on this river, consequently the environment of the marshes is already deteriorated in south of Iraq country, no agreements reached between these countries on the use and management of the shared rivers.

This paper deals with the changes and the trend of the available recorded maximum annual temperatures for Musil station starting from year 1941 until year 2011, as well as a case study of surface water resources entering Iraq for the period 1931 until 2012.

1 -1 Objective of the work
Study and analysis of the changes in the maximum temperatures at Musil station.

Study and analysis of the changes in the water inflows of upper Tigres and Euphrates rivers and their tributaries (entering Iraq), due to reservoirs construction and expected climate change.

1 -2 Tigres and Euphrates rivers basins
The basin of the Tigres River and its tributaries are shared between Iran, Iraq, Syria and Turkey whereas Euphrates River basins are shared between Turkey, Syria and Iraq Fig. (1). The percentage of the Euphrates River yearly inflows, within Turkey 81.8 % of the total River inflows, and only about 9.1 % from Syria and 9.1% inside Iraq respectively.

As for the water inflows from the Tigres River and its tributaries (4), the situation is somewhat different, where the percentage coming from Turkey 41.8 %, Syria 0.4 %, and Iraq 38.4 % and from Iran is 19.4%.

Fig. (1) Tigres and Euphrates Basins

1 -3 Climate changes impact on water resources
A simple increase in average temperature results in greater evaporation from soils, from lakes and wetlands. Greater evaporation from land surfaces and water bodies, including the oceans, produces more water vapor, which translates into global precipitation increases. Those increases, however, are not evenly distributed in time and space. Those places getting much more precipitation finds that the increased precipitation offsets the greater evaporation from land and water surfaces; these places are wetter. Those places seeing only a modest increase in precipitation or no increase at all find that increased evaporation rates overshadow precipitation and total available water decreases. Finally, in combination with increased evaporation, those places receiving less precipitation are much drier than before climate change.

1 -3 – 1 Causes of climate change
The climate of the earth is dynamic and always changing through a natural cycle, the changes occurring today have been speed up because of human activity; the causes of climate change can be divided into two categories:
A - natural causes, Continental drift, solar variation (especially sunspot variation), volcanic eruptions and Earth Orbital changes.

B - Human influences such as greenhouse gases emission

1 -3 -2 Sun spot and climate change
The influence of the sun on earth's climate has been a topic scientific interest for 200 years (2). During periods of high magnetic activity, the sun emits more light especially ultra-violate light and the number of sunspots also increases. Some solar cycles have been as short as 9 years and others as long as 14 years, the most prominent of which is about 11 years in the mean.

2 – Impact of climate change on Iraq Water resources

2 -1 – Temperature changes
From the records of maximum yearly temperature at Musil station (one of the metrological stations on Tigres river inside Iraq lands), for the period 1941 up to 2011, can be observed in Fig(2) that the trend line of the relation between the years and
maximum temperature is positive, especially at year 2000 the recorded temperature was 46.5°C, which is the highest value for the period under consideration.

Fig.(2) Maximum Yearly Temperature at Musil Station

2 -2 – Water Inflows changes of Tigres and Euphrets rivers
The change in water inflows for selected periods are calculated and presented in Table (1) and Table (2), these tables are calculated from the available river inflow records of the Euphrates River at Hussaiba gauging station and for Tigres River with its tributaries inside Iraq for the period 1933 to 2012.

The change in the yearly inflows of Tigres River are shown in Table (1), two periods are selected, 1933 to 1998 for inflows of years before climatic impact and a second period for years of climate impact 1999 to 2012. This table shows there is significant decline, more than 30% in the average yearly inflows, for the period 1999 – 2012, which indicate a sever draught inflows for this period due climate impact on Tigres water resources (3).

Table (1) Tigres Yearly Inflows for period 1933 - 2012

<table>
<thead>
<tr>
<th>Period in Years</th>
<th>Upstream Musil Inflow(Mds.)</th>
<th>Total Tigres &amp; Tributaries(Mds.)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993-1998</td>
<td>21.2</td>
<td>49.2</td>
<td>Natural inflow</td>
</tr>
<tr>
<td>1999-2012</td>
<td>15.0</td>
<td>33.0</td>
<td>Climatic Impact</td>
</tr>
</tbody>
</table>

As for the yearly inflows of the Euphrates River it is illustrated in Table (2), the available recorded period (1933 to 2012), is divided into four consecutive periods, the average annual inflows for these periods shows a continuous decrease, especially in the fourth period which shows the impact of climatic changes, where the value is decreased to about 50% of the natural yearly inflows of Euphrates river and 30% of the inflows for the period 1974 to 1990.

Table (2) Euphrates yearly Inflows for period 1933 – 2012

<table>
<thead>
<tr>
<th>Period in Years</th>
<th>Hussaiba Inflow (Mds.)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1933 - 1973</td>
<td>30.0</td>
<td>Natural Flow</td>
</tr>
<tr>
<td>1974 - 1990</td>
<td>23.22</td>
<td>Before Ataturk Dam Construction</td>
</tr>
<tr>
<td>1991 - 1998</td>
<td>20.34</td>
<td>During Ataturk Filling and Operation</td>
</tr>
<tr>
<td>1999 - 2012</td>
<td>15.82</td>
<td>Water use &amp; Climatic Impact</td>
</tr>
</tbody>
</table>

2 -3 Annual water resources changes in the Tigris and Euphrates (5)
Water resources of Tigris and Euphrates rivers and their tributaries subjected to a sever decrease to their yearly inflows due to
set up reservoirs on their tributaries at neighboring countries, especially on the Euphrates River. It can be seen from Figure (3)&Fig(4), a continues decline in the 10 years average annual inflows of Tigris and Euphrates rivers starting from the year 1970 until the year 2012, especially the years after 1999, for Tigris river Average 10 years inflows was 26.0 Mds. cubic meters at the beginning of 1970, dropped to 16.09 Mds. cubic meters at the end of year 2012, for Euphrates 10 years average inflows was 35.0 Mds. Cubic meters at the beginning of 1970, dropped to 16.09 Mds. cubic meters at the end of year 2012.

In this circumstances it is possible to divide this period into two parts, the first starting from year 1974 until 1994, a period which shows the change in inflows due to set up of reservoirs on the Tigris and Euphrates rivers, especially on the Euphrates River, and a second period, 1999 to 2012 where seeks a short period frequency for draught years of inflows for both rivers. Also in the coming months the operation of Ilisu dam will decrease the Tigris inflows which will add a new shortages to Iraqi water requirements.
Conclusions
According to the results shown above, some conclusions can be given:
1 - An increase in the annual maximum temperatures in the Mosul city is observed, especially in recent years. The recorded temperature was 46.6 degrees Celsius in the year 2000 which is the highest temperature ever recorded during the full period 1941 to 2011. The reason for the high temperatures may be due to an increase in sunspots on an ongoing basis in addition to warming (due to many factors, including the large amount of carbon dioxide emitted in the atmosphere). The period of the average cycle duration of sunspots is found to be around 11 years.
2 - Water resources of the Tigris and Euphrates rivers are affected by climate change, especially in recent years, there is an acute shortage of water resources.
3 - The implementation of the projects in the neighboring countries caused a sever reduction in Euphrates flow, in which it seriously affecting agriculture and would have major adverse consequences for large numbers of people living on this river, consequently the environment of the marshes is already deteriorated in south of Iraq country and continuing to the coming years, also in the coming months the operation of Ilisu dam will add a new shortage to Tigres river inflows.
4 - Continuous decrees In the 10 years average annual inflows for Tigres and Euphrates rivers where observed particularly from year 1970, (The commencing of reservoir construction on Euphrates river). The natural inflows of Euphrates river was 29.8 Mds. Cubic meters for the period, (1933 to 1970) and it is 16.53 Mds. for the period (2002-2012).