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Study of the Change in Levels of the Tigris and Euphrates Rivers in the Cities of Mosul and Fallujah in Mesopotamia

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Abstract: The Tigris and Euphrates rivers are the main sources of water in Iraq, which originate from outside it, which poses the problem of a decrease in their levels due to the upstream countries erecting dams, which creates a real problem in Iraq. Therefore, the dams built on them work to store water in the lakes formed behind the dams and then return it to the rivers when they decrease. River levels. The monthly rates of water discharge of the Tigris River at the Mosul Dam, as well as the monthly rates of discharge of the Euphrates River water at the Fallujah Dam, were studied from data from the National Center for Water Resources Management in Iraq for the years 2018 to 2020. It was found that river levels reach their highest values in the spring, based on knowing the amount of water discharge at the front of the dams. We also note that the year 2019 is associated with the highest water discharge values because it is the year with the heaviest rainfall during the study period.

Keywords: Tigris; Euphrates; Mosul Dam; Fallujah Dam; discharge.

1. Introduction

Mesopotamia refers to a wide region, which includes all of Iraq, eastern Syria, southeastern Turkey, and parts of western Iran and Kuwait. The word Mesopotamia means that it is the land between the Tigris and Euphrates rivers. These two rivers originate in eastern Turkey, but from two different sources far from... Each other, where the origin of these waters is from winter rains and the melting of ice in both the Taurus and Zagros Mountains, and then they flow to southeastern Turkey, then northern Syria, and meet in Iraq and finally empty into the Persian Gulf. The region's climate is characterized as semi-arid, with a vast desert area in the north, and a large area of swamps, marshes, lakes, mudflats and reed banks in the south, with an area of 15,000 km^2 [1].

The region of the Tigris and Euphrates rivers is characterized by its small tributaries that are fed by shallow fresh lakes and swamp water. The sources of these two rivers remained natural. Still, in the sixties and seventies of the twentieth century, Turkey began a project in southeastern Anatolia, and the goal of that project was to build dams on the

course of the Tigris rivers. and the Euphrates, this led to major water problems and negative environmental impacts. In the 1980s, the region was exposed to great danger due to the war that broke out between the states of Iran and Iraq within its borders. Thus, the wetlands in Iraq dried up completely and remained in this state for a long time.

Today, the region is witnessing major changes in Temperatures are accompanied by little rainfall in the lower reaches of the Tigris and Euphrates rivers, and heavy rains in the highlands of that region, where snowfall and its melting during the spring lead to an increase in river levels [2].

Dams are among the largest water installations built by humans on perennial rivers or seasonal valleys to store their water, regulate its flow, ward off the dangers of floods and drought seasons, use water to generate clean electrical energy, compensate for the shortage of drinking water and domestic uses, industry, tourism, and irrigated agriculture, and regulate navigation. River and environmental conservation [3]. In this research, we will discuss the Mosul Dam on the Tigris River and the Fallujah Dam on the Euphrates River as shown in Figure 1.

Figure 1. Iraqi rivers and dams.

Mosul Dam is about 50 km north of the city of Mosul in Nineveh Governorate, northern Iraq, on the course of the Tigris River. It was opened in 1986. It is 3.2 km long and 131 meters high. It is considered the largest dam in Iraq. The dam works to generate electrical energy and provide water for irrigation downstream, and it reserves about 11.1 km. meters of water and provides the main electricity to the dam with a capacity of 750 megabytes, as shown in Figure 2 [4].

The Fallujah Dam is located on the Euphrates River, about 5 km south of the city of Fallujah. It consists of ten openings with crescent gates. It discharges into the Euphrates River at a capacity of 3,600 m3/s, with the highest level in the river at its front, which is 44.79 m above sea level. The dam has a fish passage, 144.90 m long and 8 in width. Among its most important facilities are the main dam, the fish passage, the unified canal regulator, and the sedimentation basin regulator. The importance of its construction lies in securing

water and irrigating lands within the Saqlawiyah, Abu Ghraib, Radwaniyah, Yusufiyah, Latifiyah, and Alexandria projects, and in regulating the drainage between the Ramadi Dam and the Hindiyah Dam in the south. The dam was completely completed in 1985, as shown in Figure 2 [5].

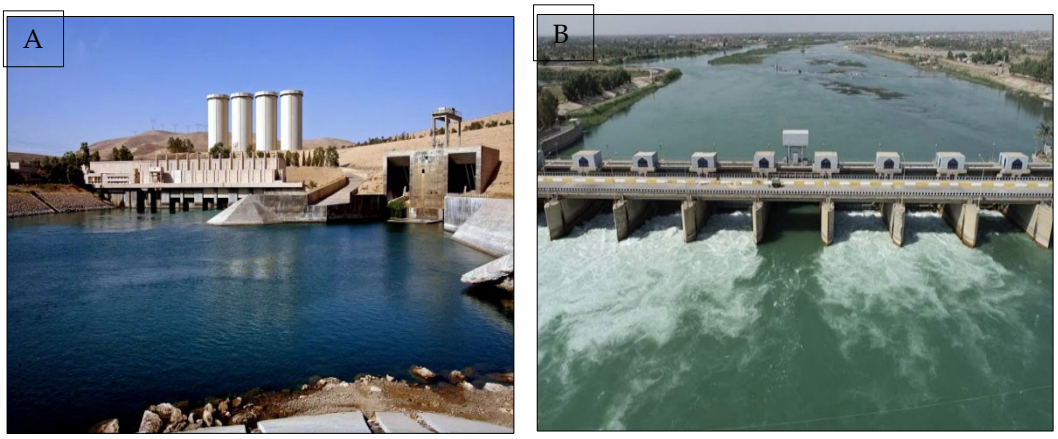

Figure 2. (A) Mosul dam, (B) Fallujah dam

In (2016) water flow changes of the Tigris and Euphrates rivers were studied and it was noted that there is a natural trend of decline in the flows of the Tigris and Euphrates rivers, which means that changes in flow are closely related to natural features compared to human interventions in the Tigris and Euphrates basins. These disturbing results represent calls for all countries in the Middle East to create a new joint water diplomacy [6].

In 2017 a study found that water can be used as a weapon of war during hostilities and as a source of cooperation. In an attempt to contribute to the current debate on the relationship between water and security between countries, I explained the historical background of relations between three countries regarding the problem of water scarcity, and then later discussed the reasons for the rapprochement between Turkey, Syria and Iraq, which led to unprecedented cooperation relations in dealing with water scarcity with the beginning of the twenty-first century. Finally, an analysis of the civil war in Syria as a case study to understand how water scarcity can be a source of conflict within states, and at the same time for cooperative relations between Turkey and Syria even in the midst of a crisis. In addition, the problem of water scarcity worsened in parallel with the sectarian war in Iraq at that time [7].

Another study also showed that the Tigris and Euphrates basin includes 144 species of amphibians and reptiles. The main threats to its survival are represented by the construction of dams, continuous habitat loss and fragmentation, wars and political conflicts, in addition to water pollution, and illegal fishing methods [8].

In this research, we used the amount of water discharge at the front and back of the Mosul and Fallujah Dams for the years 2018-2020 to identify the levels of the Tigris and Euphrates rivers for the same period.

2. Materials and Methods

The data used represent monthly rates of discharge levels of the Tigris and Euphrates rivers, taken from the National Center for Water Resources Management for the Mosul Dam and Fallujah Dam. The data were monthly for the years from 2018 to 2020.

3. Results and Discussion

The level of the Tigris River at the front and rear of the Mosul Dam will be studied, as well as the level of the Euphrates River at the front and rear of the Fallujah Dam for the years 2018, 2019 and 2020.

3.1. Mosul Dam

The Mosul Dam is located on the Tigris River in the Mosul Governorate in northern Iraq, between longitudes 25.41 and 15.44 east and between latitudes 15.34 and 3.37 north.

3.1.1. Front of the dam

Figure 3 represents the levels of the Tigris River at the front of the dam as monthly averages during the years of the study.

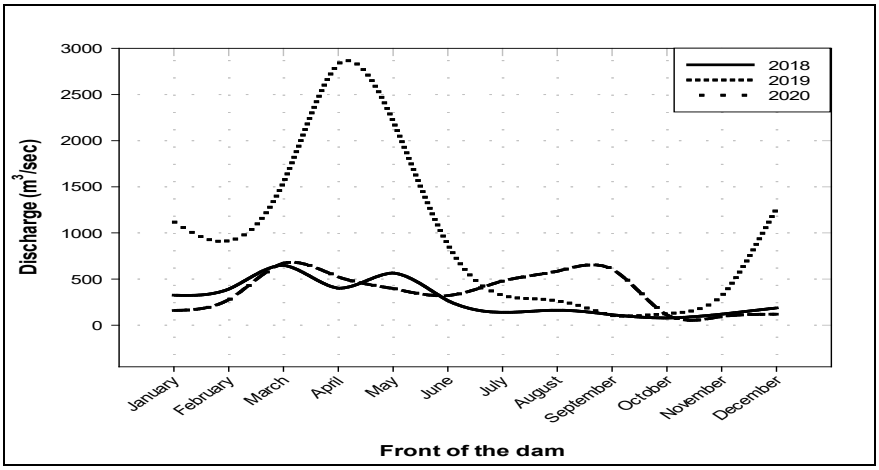

Figure 3. Discharge in the front of Mosul dam.

It was noted that the highest values of the Tigris River level at the front of the dam are in the months of March, April, and May, which are the months of the beginning of spring and the melting of snow at the water sources. The river, the river level rises, and these values represent the amount of water entering the dam. We also note that the highest river levels were in 2019, amounting to 5% of the total annual discharge because it was a year of heavy rainfall with a discharge rate of more than 990 m3/s, which is more than three times the water discharge for the years 2018 and 2020, which represents 48%, 37% respectively, of the total annual discharge, as shown in Table 1.

Table 1. Monthly rate of discharge in the front of Mosul dam.

Months	**2018**	**2019**	**2020**
January	325	1119	160
February	391	918	278
March	**649**	**1563**	**673**
April	**401**	**2837**	**522**
May	**565**	**2197**	**397**
June	266	862	321
July	140	321	480
August	162	261	585
September	113	103	608
October	79	125	111

November	120	323	95
December	187	1274	119
Summation	3398	11903	4349
%	**48%**	**55%**	**37%**

3.1.2. Back of the dam

Figure 4 represents the levels of the Tigris River at the back of the dam as monthly averages during the years of the study.

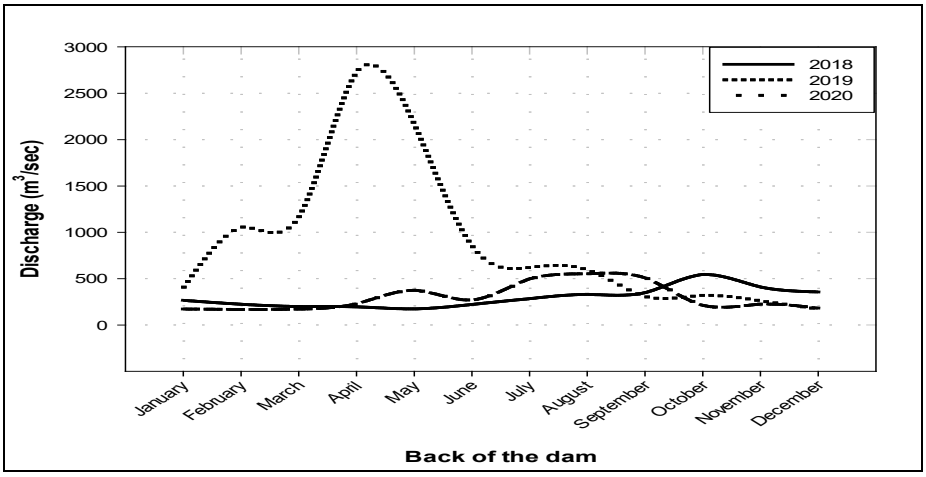

Figure 4. Discharge in the back of Mosul dam.

The figure shows the monthly rate of water discharge from the back of the dam. This is done to avoid filling the dam completely to reduce the pressure on it. We note that the highest discharge values are from July to October (which represent the summer months in Iraq) in the years 2018 and 2020, representing 42% and 44%, respectively, of the river's annual discharge, while we note in 2019 that the highest discharge values occur between the months of March and May. (Representing the summer months in Iraq) and representing 57% of the annual discharge, as this year witnessed large amounts of rain in addition to the melting of snow at the headwaters of the Tigris River, as shown in table 2.

Table 2. Monthly rate of discharge in the back of Mosul dam.

Months	**2018**	**2019**	**2020**
January	267	409	175
February	225	1059	170
March	200	**1173**	175
April	197	**2738**	231
May	175	**2161**	377
June	223	852	272
July	**285**	623	**500**
August	**332**	594	**555**
September	**350**	308	**512**
October	**546**	322	216
November	412	262	228
December	358	175	185
Summation	3570	10676	3596
%	**42%**	**57%**	**44%**

3.2. Fallujah Dam

Fallujah Dam is located on the Euphrates River in Anbar Governorate, western Iraq, between latitudes (31° and 35°) to the north and longitudes (39° and 44°) to the east.

3.2.1. Front of the dam

Figure 5 shows the monthly rates of water discharge from the Euphrates River at the front of the Fallujah Dam.

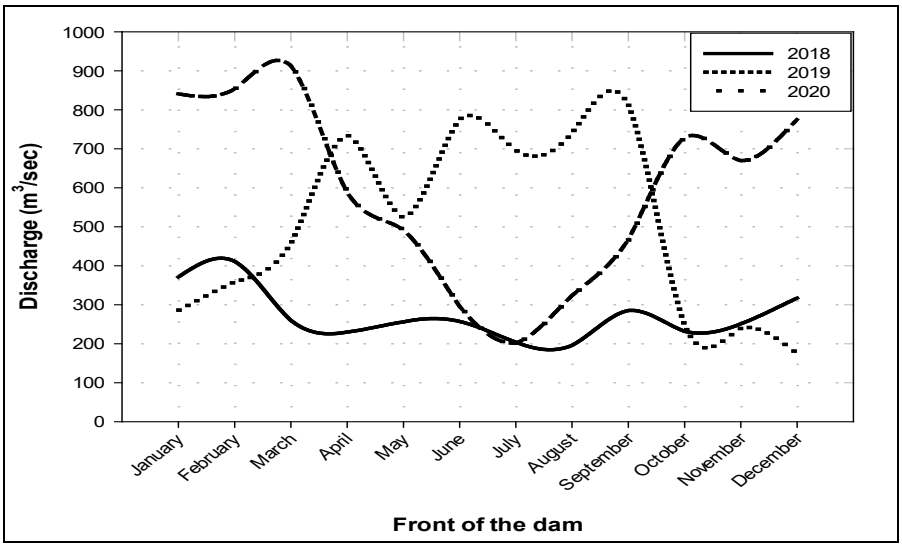

Figure 5. Discharge in the front of Fallujah dam.

It is noted that the highest values of drainage in 2018 and 2020 are in the winter and the lowest values are in the summer, but in general the drainage values for the year 2020 are twice what they are for the year 2018 due to the increase in the amount of rain over the year 2018, which is considered a dry year, as for the year 2019, which was characterized by an increase in the amount of rain. In the region, which caused severe flooding in some areas in the Jazeera Desert within Anbar Governorate, we note that the highest values of the monthly rate of discharge at the front of the dam are during the spring and summer months from April to September, which is equal to 71% of the annual amount of discharge, which indicates a rise in the water level of the Euphrates. Largely as a result of the melting of snow at the river's sources during the spring, in addition to the large amounts of rain that fell in the winter, as shown in table 3.

Table 3. Monthly rate of discharge in the front of Fallujah dam.

Months	2018	2019	2020
January	371	286	841
February	**411**	359	**854**
March	**260**	460	**913**
April	230	**735**	589
May	256	**524**	492
June	257	**777**	296
July	204	**696**	202
August	196	**742**	323
September	285	**811**	467
October	232	245	**729**
November	**251**	240	**670**

December	**317**	174	**775**
Summation	3270	6049	7151
%	**38%**	**71%**	**55%**

3.2.2. Back of the dam

Figure 6 represents the levels of the Euphrates River at the back of the dam as monthly averages during the years of the study.

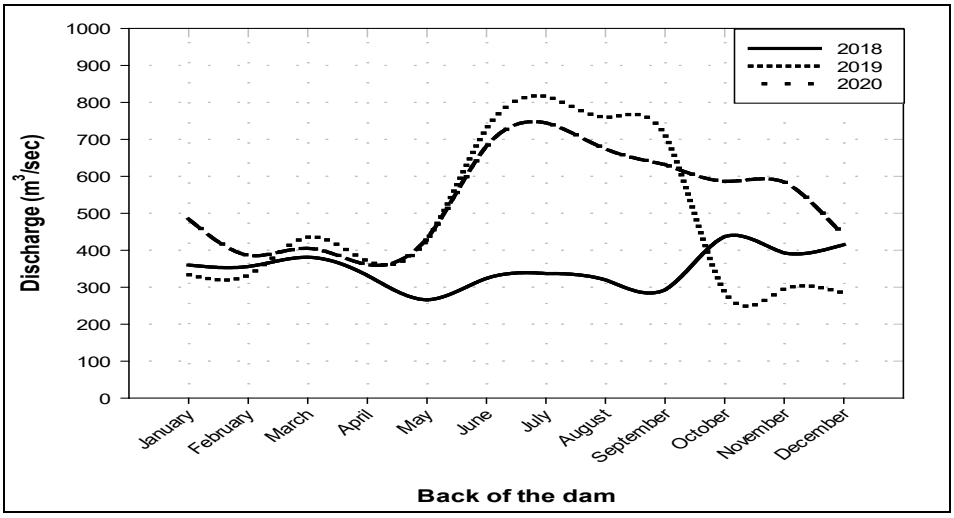

Figure 6. Discharge in the back of Fallujah dam.

It is noted that in 2018, the monthly rates of water discharge from the back of the dam are at their lowest values in summer, and they rise slightly in October to December at a rate of 30% of the value of the annual rate as a result of the lack of rain this year, while in the years 2019 and 2020, the values of the monthly average are the highest. The river's water drainage between June and September increased by 52% and 43%, respectively, as shown in table 4. The reason for this is due to the increased amounts of rain during these years, which led to torrential rains in some areas, which made it necessary to empty dams to avoid collapse.

Table 4. Monthly rate of discharge in the back of Fallujah dam.

Months	**2018**	**2019**	**2020**
January	360	334	485
February	356	333	386
March	381	436	405
April	332	370	361
May	266	430	432
June	324	***732***	***682***
July	337	***817***	***745***
August	320	***760***	***675***
September	293	***711***	***632***
October	***437***	285	587
November	***393***	296	585
December	***415***	284	441
Summation	4214	5788	6416
%	***30%***	***52%***	***43%***

4. Conclusions

From the above, we note that the levels of the Tigris and Euphrates rivers depend on the amounts of rain in addition to the melting of snow at the sources in the spring, and this is clearly evident from the high rates of discharge at the front of the dams, where excess water is diverted to the lakes located behind the dams, and when the dams are full, the rates of discharge at the back of the dam to divert water downstream and reduce pressure on the dams. We also note that the year 2018 is accompanied by the highest values of monthly water discharge rates due to it being one of the highest years in terms of rainfall amounts during the years of the study.

Supplementary Materials: No supporting information.

Author Contributions: Nagham T. Ibraheem completed the experiments; Hasan M. Azeez prepared the draft

Funding: Unavailable

Data Availability Statement: We declare that the submitted manuscript is our work, which has not been published before and is not currently being considered for publication elsewhere.

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Conflicts of Interest: No interest

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