The impact of the eighth largest dam (under construction) in Iraq on the Tigris River (Makhool Dam as a review paper)

Abstract

At the beginning of the twentieth century, irrigation projects began in Iraq. Although there are currently seven large dams in this country, there has recently been a ministerial request to build the eighth large dam, or Makhool Dam. Unfortunately, ambiguity is the predominant feature regarding cases or events of Makhool Dam. In this paper, a review is presented as an answer to a number of questions regarding the above dam.

1- Introduction

Dams are one of the largest and most massive civil constructions. Dams are usually built on: river valleys, torrents, or depressions. Dams are used to hold, collect and store water for promising purposes. In dry seasons, the stored water is used to improve water quality, especially when the flow of rivers is low to secure the water needs of various activities. Over the past six decades, the number and storage volumes of dams and reservoirs have increased significantly, today reaching nearly 50,000 large dams defined as more than 15m in operation all over the world (Lehner et al. 2011).

In Iraq, rivers are characterized by varying discharges. This variation occurs from year to year and season to season, depending on the characteristics of the water year. A wet year could lead to major floods and disasters. A dry water year could lead to a drought and as a result crop failure and massive damage to livestock and soil (Ibtisam et al. 2014). Thus, there is still an urgent need to build large dams in Iraq, even though this country has a history of building irrigation projects.

At the beginning of the twentieth century, irrigation projects began in Iraq. The first water project was established in 1913 and was the Al-Hindiya Barrage. In the 1930s, the Al Kut Barrage and the Al Gharaf Regulator were established, and then various water projects followed. The aim of these projects was to regulate water flow to prevent flood hazards, and to generate electricity and irrigation. Due to the increase in water requirements as a result of the development of life in Iraq, the need to change or exceed the old goals of moving to large storage projects was becoming very clear. Therefore, a number of large dams were constructed in Iraq in the following years, as the first dam was built in 1995 on the Little Zab River, which was the Dokan Dam, and the last dam in 1999 was Al-Azim Dam on the Al-Azim River, in addition to other water facilities completed by the Iraqi governments (Hamdan 2014). Although there are currently seven large dams in Iraq, there has been a ministerial request recently for the construction of the 8th large dam (Makhool Dam).

Unfortunately, ambiguity is the dominant feature regarding the Makhool Dam issues or events. Although this dam has been described as one of the most important water projects and the most important strategic project on the Tigris River, there are few studies and information available about it. Therefore, the aim of this paper is to remove this ambiguity. This will be done by answering the following questions that can be considered a review of what is available from previous studies and what has been recently updated regarding the Makhool Dam: -

- What are the general details of the dam?
- What are the desired goals of building dam?
- What is the geological setting of Makhool Project?
- How will the proposed dam reservoir affect areas adjacent (floodplains)?
- What are the recently approved official procedures for the dam?

2- Discussion

2-1 What are the general details of the dam?

Makhool Dam is still under construction. Construction work on this dam began in 2001, but work stopped after 2003 for various financial, political and security reasons. The Makhool Dam is located on the Tigris River, which is 30 kilometers northwest of the city of Baiji. In addition, it is about 15 kilometers from the confluence of the Lesser Zab and the Tigris (see Fig 1) (Sissakian et al. 2006).

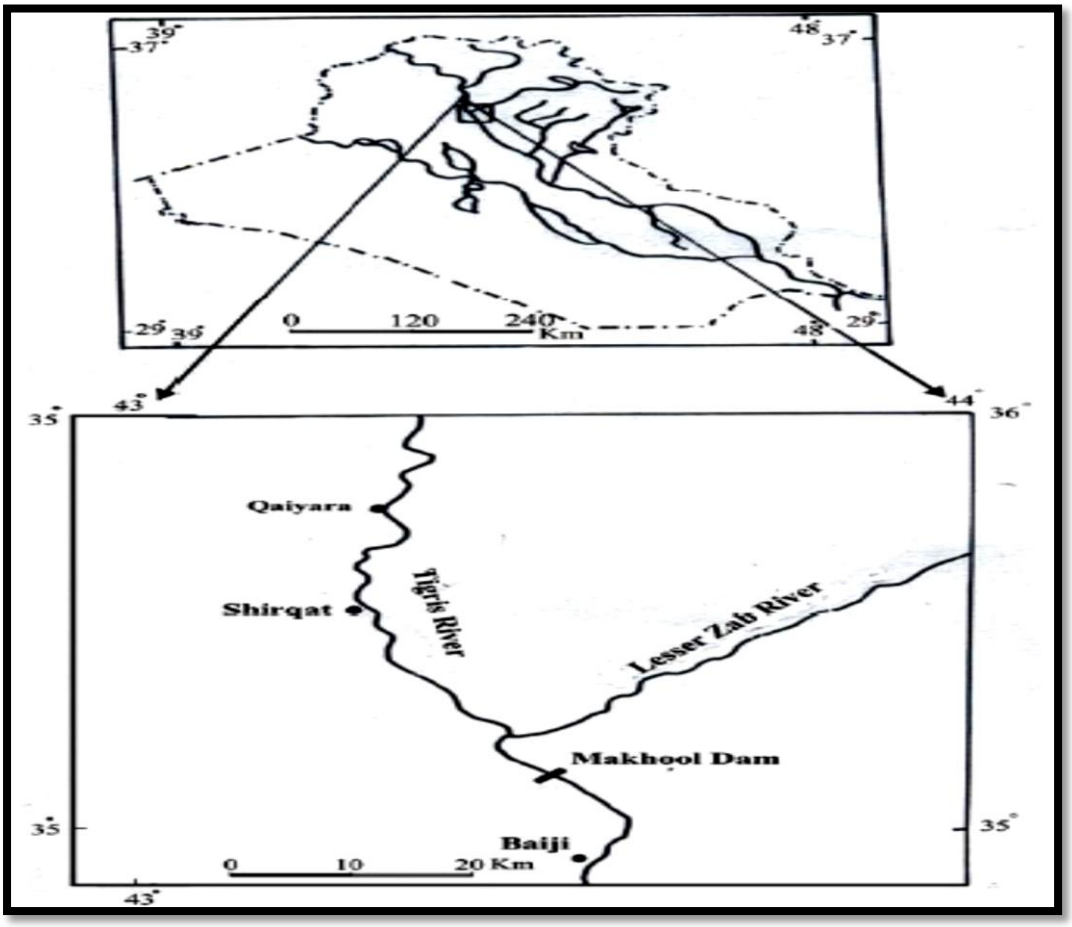

Fig (1). Makhool Dam location on: Iraq map and the column of the Tigris River between the town of Al-Shirqat and Baiji (Sissakian et al. 2006).

Makhool Dam was designed to be the embankment dam. So, the dam body will consists of different fill materials (soil and rocks) with special specifications that prevent water leakage. The design height of the dam is 150 m (a.s.l). This means that everything below the level of 150 along the Tigris and Little Zab will be submerged into the water when the reservoir is filled. Accordingly, the lake that will be formed behind the dam will extend north of the city of Shirqat by about 4 km, and north of the village of Al-Eilat by about 1 km. Tigris River level at the dam site is 137 meters, so the height of the dam will be about 16m for the level of maximum possible flood. For more details on the Makhool Dam, Table 1 is listed as follows.

Table-1: General information about Makhool Dam (Irrigation Ministry 2001)

Dam crest level	160 m (a.s.l.)
Maximum height of dam is at the lowest point at the river bed	56 m
Dam crest width	12 m
Dam length at the crest level	3670 m
Maximum possible flood level	152.15 (a.s.l.)
Maximum annual operating level	150 m (a.s.l.)
Minimum annual operating level	140 m (a.s.l.)
Flood storage volume at the level of 152.15 (a.s.l.)	2,665 Billion cubic meters
Storage volume at the level of 150 (a.s.l.)	2,222 Billion cubic meters
Storage volume at the level of 140 (a.s.l.)	0,744 Billion cubic meters
Annually used storage volume	1,478 Billion cubic meters
Storage area at the level of 150 (a.s.l.)	195,6 Km^2
Bottom gated spillway discharge	22,225 m^3/s
Non-gated emergency spillway discharge	1338 m^3/s
Annually possible electric generation	1940 Bil Kwat.h

2-2 What are the desired goals of building dam?

Iraq suffers from a suffocating water crisis for many reasons. The effects of climate change are one such reason (Al-Ansari 2018 & Al-Ansari et al. 2014). The water policies of countries neighboring Iraq are another reason because they are trying hard to monopolize the waters of the shared rivers or the waters across the border (Al-Shammari 2020). Water management in Iraq can be considered more dangerous than the above two reasons due to the inefficiency of transportation and irrigation, so it can be considered a real crisis as a result of the inability to achieve or meet water needs. Therefore, solutions are the actual need for irrigation projects (such as dams) that could address this crisis in addition to focusing on the use of modern irrigation methods. As a result, the Makhool Dam, which is one of these solutions, has been adopted by the Iraqi government to manage water resources (Ibrahim 2021). In general, it can be said that the constructing of Makhool Dam will achieve several goals such as: flood mitigation, regulating the flow of the river and making use of water for irrigation purposes, generating electric power, navigation and improving the quality of water. This dam will also bring other side benefits, such as: developing fisheries, encouraging tourism, and improving the environment (Irrigation Ministry 2001).

Makhool Dam can support Samarra Barrage in mitigating flood waves. The Lower (or Lesser) and Upper Zab Rivers are most important tributaries of Tigris River in Northern Iraq region (see figure 2) and they supply Tigris River with more than forty percentage of its water yield. The Lower Zab River is controlled by the Dokan Dam, while the Upper Zab River is not controlled by any hydraulic structure as a result of the Bakhma Dam construction halt and its annual discharge rate is 13.8 Km^3 (Awchi 2014 & Said 2009). In flood seasons, the water flowing from the Mosul Dam together with the uncontrolled water flows of the Upper Zab River may cause great pressure as a great danger to the Samarra Barrage because it is not allowed to release high water discharges from this barrage. As for the reason for not allowing the release of high water discharges, it will be mentioned as follows. The Samarra Barrage and the Mosul Dam are flood protection structures for the city of Baghdad (the capital of the Republic of Iraq) (see Figure 3). According to the Ministry of Water Resources 2020, the construction of various facilities on the flood plain of the Tigris River in Baghdad has become a reason for the impossibility of passing high water discharges within its geographical boundaries compared to the flood of 1988, when 3,049 cubic meters per second passed in

April. As a result, it is suggested that the Makhool Dam should be located after or down-stream of the confluence of the Upper Zab River with the Tigris River and the up-stream of the Samarra Barrage and that the discharge of water released from above the dam should not exceed 12,000 m^3/s, of which 9000 m^3/s is discharged into Lake Tharthar by the Tharthar regulator, while the remaining 3000 m^3/s pass through the Samarra Barrage to protect the Iraqi capital (Baghdad) from the risk of flooding (Abdul Mohsen & Al-Aqili 2012). Both of Tharthar Regulator and Samarra Barrage are part of Samarra Water System.

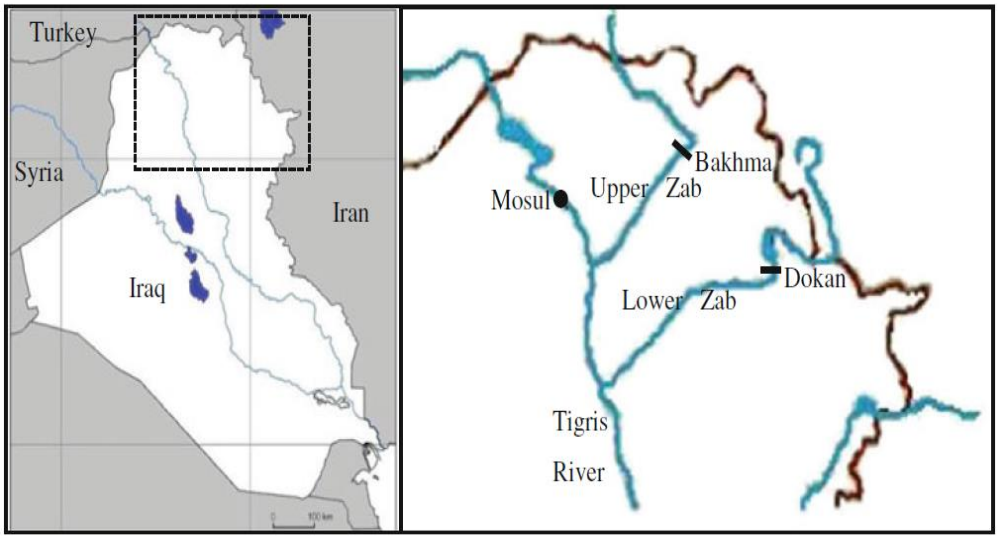

Fig (2). Scheme showing the Tigris River and its tributaries (the Upper and Lower Zab Rivers) and their location on the map of Iraq (Awchi 2014).

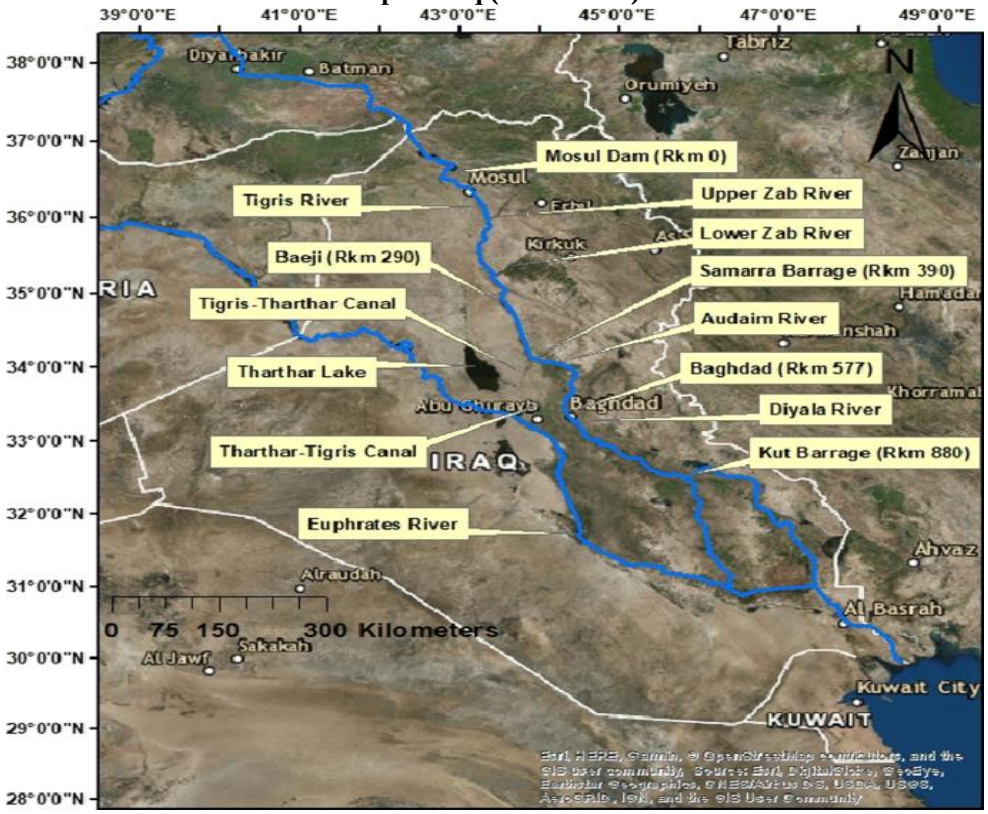

Fig (3). A satellite image showing: a map of Iraq, Rivers, and irrigation structures (Al-Murib & Wells 2019).

2-3 What is the geological setting of Makhool Project?

Makhool Project is situated within the Zone of Low Folded. At the dam site and the reservoir, the exposed rocks belong to the Injana and Fatha Formations (Sissakian et al. 2006). The two formations (shown in Fig. 4) will be briefly described as follows:-

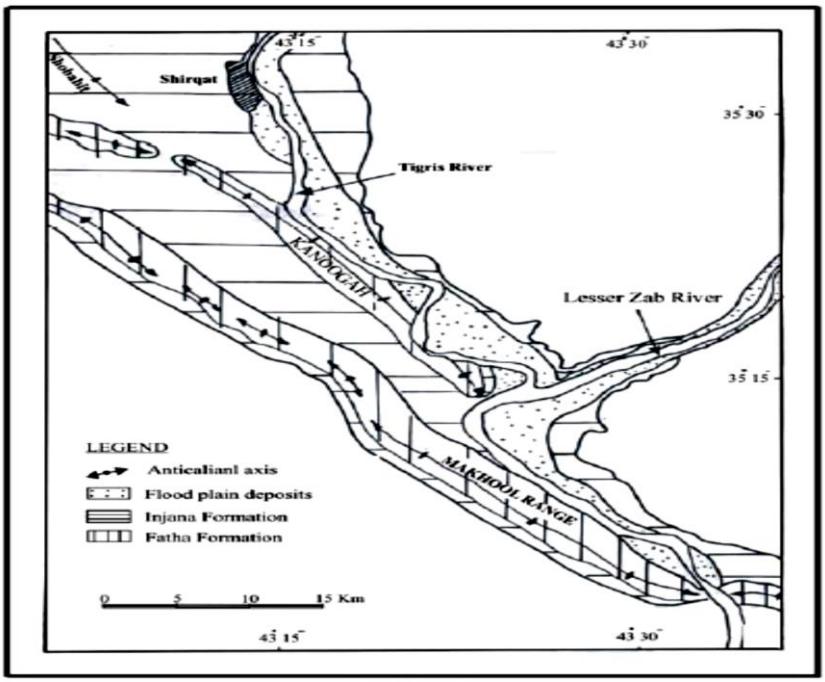

Fig (4). The geological map of Makhool Project (Sissakian et al. 2006).

a) Al-Fatha Formation, in Iraq is one of the major problematic geological formations. It covers large parts of the Iraqi territory, particularly in the western-central part and the north-central part as well. This formation is called ex-Lower Fars and is from the Middle Miocene of the Age. Al-Fatha Formation is made up of cyclic sediments and each ideal cycle be composed of marl and limestone as well as gypsum. As a result of intense karstification, the formation rocks have caused massive damage to the structures constructed on its exposure areas (Sissakian et al. 2016). Karst is usually defined as a topography formed as result of the dissolution of soluble rocks such as dolomite, limestone, and gypsum. It is also characterized by systems of underground drainage with caves and sinkholes (Jackson 1997 & The University of Texas at Austin 2006).

b) The Injana Formation, in Iraq, is found on a large scale and extends over large areas in Turkey, Syria and Iran. This formation is from the Upper Miocene and is called ex- Upper Fars. The Injana Formation is mainly described as a semi-continental to coarse continental sandstone as well as the medium-grained sandstone rich in carbonate alternating with mudstones, brownish-red clays and marls with rare freshwater limestone (Al-Juboury 2009).

According to the Iraqi Ministry of Water Resources (2020), modern technologies for the implementation of dams make it possible to build a dam with maximum safety at the proposed Makhool site even though the foundation of this dam contains gypsum materials.

2-4 How will the proposed dam reservoir affect areas adjacent (floodplains)?

Constructing Makhool Reservoir will result in a number of changes to the surroundings. If the Makhool Dam is to be commissioned at a normal operating level of 150 m a.s.l., its reservoir will flood 18 villages with a total population of about 39,000, according to the 1977 census. It will also flood 24 primary schools, 6 health centers and 9 water projects. In addition, the area of flooded agricultural lands will reach 44,000 dunam. Furthermore, the archaeological sites located within the dam's reservoir are 12 sites, with the possibility of other undiscovered sites, so great efforts must be made to save these sites. The number of affected villages will increase to 21 villages with a population of 49,013 inhabitants when the level of flooding is taken into account for the level of land expropriation (156 m a.s.l.) (Irrigation Ministry 2001).

Large dams can be criticized for their negative environment. Public health concern has focused largely on the vector-borne diseases (Baird and Green 2020, Lerer and Scudder 1999). For example, a new environment suitable for the breeding of malaria mosquitoes and schistosoma larvae will be created as a result of the creation of the Makhool Reservoir. Therefore, necessary precautions must be taken to prevent the spread of these two endemic diseases. As well, reservoir water should not be used for drinking purposes except after filtering and sterilization to prevent the spread of typhoid.

2-5 What is the current position of work at Makhool Dam?

In 2020 & 2021, ministerial efforts have created a major shift in Makhool Dam events. On 23/7/2020, the Ministry of Water Resources announced that it had obtained the approval of the Energy Committee and the Supreme Water Committee to implement the Makhool Dam in Salah al-Din (Iraqi Ministry of Water Resources 2020).

On 23/8/2020, a meeting was held between the Minister of Water Resources and Planning. They discussed the possibility of implementing the Makhool Dam. The Minister of Water Resources confirmed that his ministry had completed all the requirements of the Makhool Dam project, including updating designs and reviewing studies. He pointed out that these requirements took into account the nature of the land on which the dam will be built, and its side effects on the population. He also stressed that the project is of very great importance in terms of securing water storage, supporting agriculture, and keeping the risk of floods away from the capital, Baghdad (Planning Ministry 2020).

On 23/9/2020, a meeting was held between the Minister of Culture and the Minister of Water Resources. They agreed to cooperate in building the Makhool Dam. The Minister of Water Resources warned that the archaeological area in the Assyrian Citadel and its surroundings was under threat due to the lack of control over the Upper Zab River. The high velocity of that river caused the erosion and collapse of this Citadel. He stressed that delaying the protection of the Assyrian Citadel did not serve the interest of any party, and that the construction of the dam would reduce the speed of that river to zero. He, also, stressed that it would be taken into account that the construction of the dam would lead to a rise in the water level in the area, which might result in future risks, so protection expanded to include all archaeological areas, and extend to Sharqat (Iraqi Culture Ministry 2020).

As a result of the aforementioned ministerial meetings, the Iraqi Ministry of Water Resources (2021) announced on 14/4/2021 that the Minister of Water Resources had laid the foundation stone for the strategic Makhool Dam project in Salah al-Din Governorate, in the presence of the Governor of Salah al-Din, the Governor of Kirkuk, and the advanced technical staff of the Ministry of Water Resources. The

minister said during the foundation stone laying ceremony that his ministry had completed all the requirements of this vital and important project with the approval of the Ministry of Planning to include it in the current year's budget, with direct support from the Prime Minister. He added that this project would be one of the most important projects implemented by the ministry after 2003, by 100% Iraqi hands in terms of design, supervision and implementation.

3- Conclusion

In this paper, a number of answers are presented to a number of questions to remove ambiguity related to the Makhool Dam issues as much as possible. Construction of this dam was started in 2001, but for several reasons, work on it was suspended. Rocks exposed at the dam and reservoir site belong to the Injana and Fatah formations. The percentage of water-soluble gypsum materials in the above formations can be controlled to provide maximum safety through the use of modern technologies used in the implementation of dams. Although a number of properties, whether residential, agricultural or governmental, in addition to archaeological sites will be submerged in the event of the implementation of the dam, there will be government guarantees for financial compensation and preservation of archaeological sites by modifying the dam designs. With serious ministerial efforts, it was announced on 14/4/2021 that the foundation stone would be laid to complete the construction of the dam.

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