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The Effect of Water on the Formation of River Bends in the Course of the Tigris River in Baghdad Governorate

By

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Abstract

The research tagged (the effect of water on the formation of river bends in the Tigris River stream in Baghdad Governorate) aims to identify the natural position of the Tigris River in Baghdad and the reasons that led to the formation of the river bends in this stream through the study and analysis of the natural and human characteristics of the area. The research reached several conclusions, the most important of which are: the variation in climatic conditions, especially wind, heat and humidity, which in turn led to the variation in the amount of rain and its absence in the months (July - August - September) and in the environment suitable for chemical and physical weathering processes in the rocks and components of the two banks of the river, meaning that it is in addition to the role of Tigris River waters shape river bends in terms of their susceptibility to erosion. Man, and his various activities also play a key role in the inequality by stiffening the area adjacent to the river, which leads to the formation of areas that differ in the degree of their solidity and the degree of erosion, and consequently the formation of river bends.

Keywords*:* Impact of Water, River Bends, Tigris River, Baghdad.

Introduction

River torsions are a natural phenomenon that accompanies riverine watercourses in the stages of maturation and aging. This phenomenon is related to a group of factors that can be distinguished in a particular section of the river, which are (moderate slope, coherent river sides of mud and silt - an incoherent riverbed of moving gravel sediments and sand).The passage of the Tigris River inside Baghdad has a clear impact on the diversity of phenomena on both sides of the river, which leads to the diversity of human activity (residential, agricultural or construction), which is the main reason for the emergence of the city of Baghdad in this position of the sedimentary plain, which represents a wide concavity accompanied by varying heights between the area And another, which led to the Tigris River bends in the area, and when its load increases, its flow rate decreases and it begins to precipitate. These sediments form barriers in the stream that gradually enlarge and later turn into islands, which leads to the division of the stream into two or more parts. When the river water passes between these islands, it gradually begins to search the outer banks, which leads to the curvature of the stream, and by continuing the search process in the concave side and the accumulation of sediments, these curvatures turn into river bends. Hence, this study came to explain the effect of water in the formation of bends in the Tigris River and the change of the morphology of the river course and the region.The research is centered on a main problem: does the water of the Tigris River affect the formation of the river bends and change the morphology of the river course and the area?

Hypothesis of the study:

The hypothesis comes to clarify the initial answer to the research problem: the waters

of the Tigris River have a clear impact on the formation of the river bends and change the morphology of the river and the region.

I*mportance of the study:*

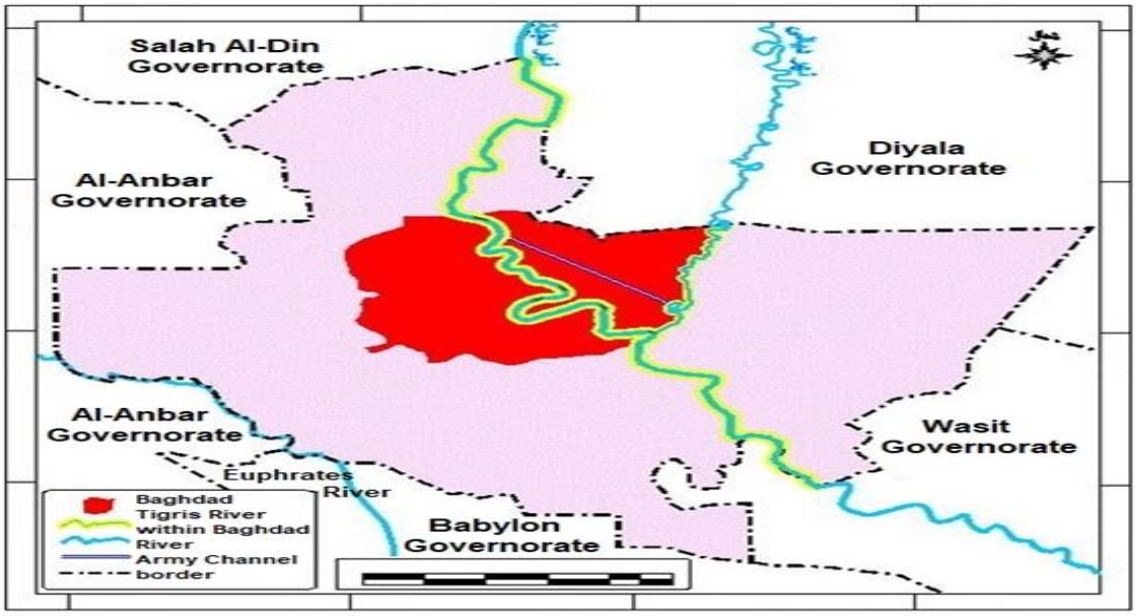
The importance of the research is to identify the role of the Tigris River waters in shaping the river bends in Baghdad, and what is the importance of these bends in changing the morphology of the region.

Objectives of the study:

- Studying the stages of Tigris River in Baghdad in the stages of maturity and aging and identifying the quality of sediments.
- Identifying the natural position of the area, the river bends, and the factors that led to its formation.
- -Emphasizing on the role of modern technologies (GIS) in hydrological and geomorphological studies.
- Knowing the role of Tigris River water in shaping the river bends and their different phases in the river course.

District location:

The spatial limits of the study are from the entry point of the Tigris River to Baghdad in the Tarmiyah region until its exit in the Al-Madaen region, which is 141.19 km long in Baghdad Governorate as shown on map (1).



Map No. (1) *Tigris River in Baghdad Governorate/ Source: Researcher based on Arc Gis.*

Chapter One: Natural Characteristics and Shaping Factors of the River Bends.

The study of the natural characteristics and the factors that shape the river bends in the importance of identifying the reasons for their formation, as well as analyzing the water characteristics of the Tigris River, as follows:

First: Geological Structure:

The Tigris River passes in the area of the alluvial plain upon entering Baghdad. It is a geologically newly formed area, as its composition dates back to the Pleistocene era in the fourth geological time. by frequent floods. In the Tigris River we can distinguish subsurface

transverse concave folds with convex folds, as well as the presence of some long natural faults (*Baday, T. 1987, p. 90*).

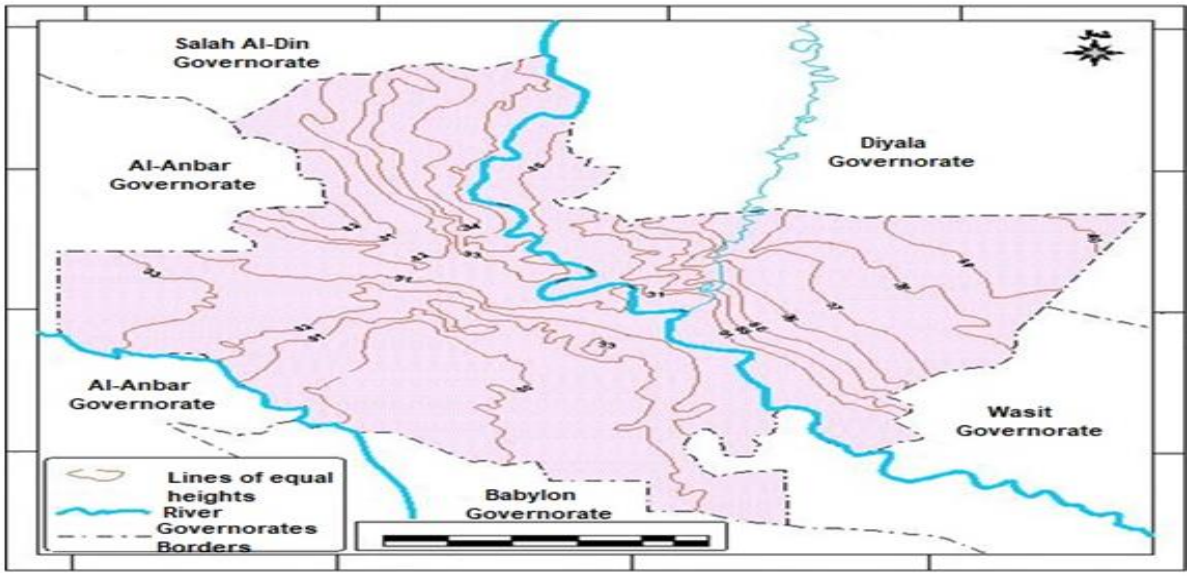
The variation in the degrees of gradient and what can be observed from the map of elevation lines no (2). Among the most important sediments of the region are the sediments of the Quaternary age, which cover the Baghdad region, which include:

Old river deposits: that includes the sediments of ancient rivers dating back to the Pleistocene era, as well as the presence of sand, gravel and silt. These sediments extend for 5-10 km on both sides of the Tigris River, and their thickness ranges between 5-6 m.

Modern river deposits: belonging to the modern era and represented by the riverine and alluvial sediments of the Tigris and Euphrates rivers, and their thickness reaches 24 m. They consist of silt, mud and sand, and carry water (Galcon, GM., 1962, pp. 191-217).

Second: The Surface:

The floods played an important role in shaping the surface of the region, which led to various phenomena of the flood river sediments. Through map (2) we note that the surface height extends between (31-40) m above sea level, characterized by the flatness of the surface and the lack of its slope as we head towards the south, as it has a slope of (32m). As the region arose at the natural concave shoulder, which is the highest part of the region, in addition to the mismatch in the lines of equal height because the soil of the region was formed as a result of different river deposits (*Al-Hiti, Sabah., 1976, p. 20*).



Map (2) Elevation Lines/ Source: Researcher based on Arc Gis.

The height of the shoulders of the rivers ranges between 3 and 5 km, while their height is more than 4 m from the neighboring lands. As for the lands on the western side of the Tigris River, they form the alluvial fan of the Abu Ghraib streams. As for the eastern side of the river, the irrigated flood fan of the streams branching from the Diyala River from the right towards the southwest forms a narrow protrusion with a height of between (38-39 m) and the lands are divided in This side into two large basins where the heights decrease.

Third: The Climate:

The study and analysis of climate elements is important in knowing the extent to which these elements affect hydrological and geomorphological phenomena in different proportions

through the degree of response of the concerned phenomenon to each of the climatic elements *(M.M.soliman, 1997, P. 70).* Here, the data of the Baghdad station for the period (1990-2020) was relied on to clarify the role of climate in the formation of the river bends of the Tigris River course is as follows:

❖ ***Temperature:***

The temperature element has a clear effect on the area, as its height leads to an increase in the chemical weathering action, while the large variation in temperature leads to an increase in the mechanical weathering action as well as its effect on the natural plant in terms of density and type. From Table (1) we note the rise in temperatures to reach their maximum in July, reaching (43.9) C, and the lowest in January (16.4) C. The rise in temperature is clearly affected by the increase in the number of hours of solar surfaces during the summer, which reaches its highest in July (12.9 hours/day) and lowest in January (5.5 hours/day). This rise is important in killing viruses in water and sterilizing it except It has a negative effect in the high rates of evaporation and the lack of water in it.

❖ ***Rain:***

The amount of rain is related to the number of atmospheric depressions that reach its maximum in the winter and decreases until it ends in the summer, which has an impact on the surface features in the areas where the rocks are not coherent. Its impact is less on both sides of the riverbed due to its lack and fluctuation. From the same table, we note that the highest rate of rainfall is in January, as it reached 29.2 mm, and the lowest in July, August and June, when it is absent. The effect of rain on the natural characteristics of the Tigris River water is shown through the lack of water drainage, which leads in turn to increase the salinity of the river.

❖ ***Wind:***

Winds have a clear impact through the erosion of the riverbanks, particularly in the dry and semi-arid regions. Erosion occurs in the concave parts of the riverbed when the winds are opposite to the direction of the watercourse, which leads to the excitement of waves that increase the demolition process in the sides (*Rahman, Hala Muhammad Abdul, 1997, P. 23).* The northwest winds prevail most days of the year, which is characterized by a high annual rate in the month of July, as it reached (4.3/ m/sec) and its lowest speed in January (2.61/m/sec/).

Table No. (1): *The climatic elements of the Baghdad station for the period from (1990-2020).*

Climatic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual Rate
Solar Radiation	5.5	7.2	8.5	9.3	10.9	12.4	12.9	12.1	10.6	8.6	7	6	9.2
Heat Great C	16.4	18.7	27.9	30.1	37	41.9	44.3	43.9	40.1	34	23.8	17.6	30.9
Heat Smallest C	4.7	6.3	10.4	16.3	22	25.3	27.9	26.7	22.4	18.5	10.1	5.6	16.3
Rain Mm	29.2	17.5	17.1	17.2	2.3	0.04	0	0	0	3.5	14.5	18.4	119.74
Wind M/S	2.61	2.9	3.4	3.4	3.5	4.1	4.3	3.7	2.99	2.69	2.68	2.64	3.2
Evaporation Mm	69	100.5	187.1	267.7	397.8	508	556	498.6	370	236.6	118.9	78.1	282
Humidity %	77.1	65	58.7	46.3	34.2	27.8	27.7	29.8	35.6	46.3	60.9	74.2	48.6

Source: The researcher, depending on the Ministry of Transport, the General Authority for Meteorology and Seismic Monitoring, Climate Department (unpublished data) 2018.

❖ ***Evaporation:***

The high temperatures and solar brightness have an effect on the high rates of evaporation and, consequently, the high rates of water losses from the river. We note that the annual rate of evaporation increased in July, reaching (556 mm), while its rate decreased in January, reaching 69 mm, due to the low temperature.

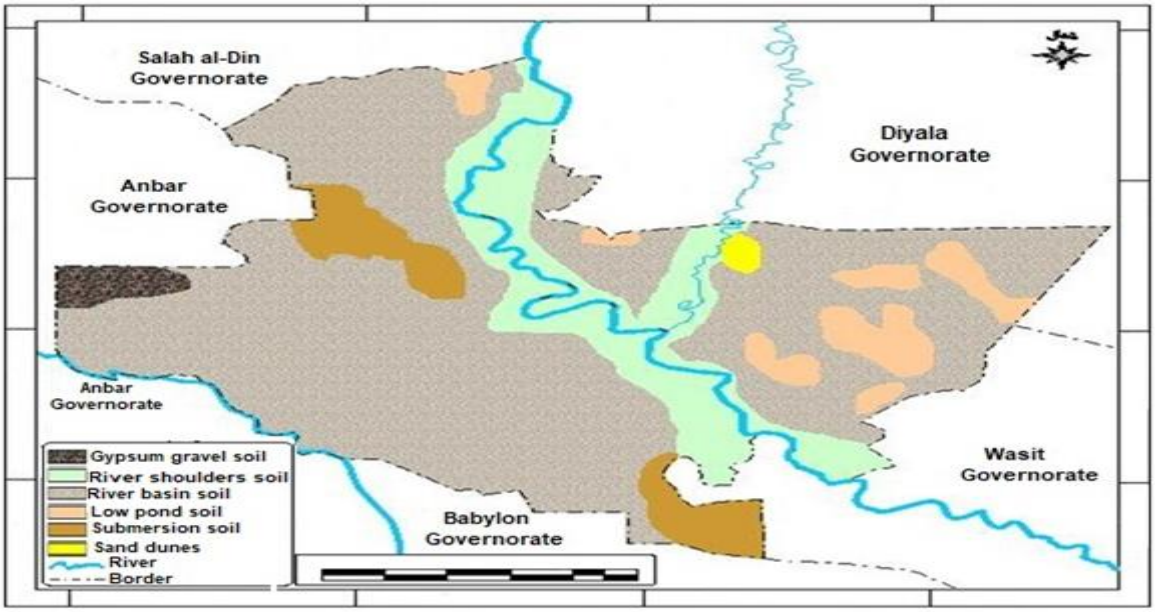
❖ ***Humidity:***

Relative humidity increases in winter, reaching its maximum in January, reaching (77.1%) and lowest in July (27.71%), due to low temperatures, lack of solar radiation and the presence of clouds in the winter and vice versa in the summer.

From what was mentioned, we note the clear variation in the annual rates of climatic elements, which in turn leads to an increase in the impact on the hydrology and morphology of the region, and thus on the diversity of use of this river.

Fourth: the soil:

Soil in any region is important to know the characteristics and quality of this soil, and then the possibility of diversifying its different uses. In general, the soil in the study area is characterized by its diversity as shown in map (3) which is characterized as soil transported by the floods of the Tigris River, since the area is part of the alluvial plain (*P.Buringh, 1960 p.106-195*), as follows:



Map No. (3) Soil Distribution. Source: Researcher based on Arc Gis.

The soil of the low basins, which is spread in the form of scattered spots as shown in the map No (3) in pink in the far north, northeast and southeast.

The immersion patrol soils and emerges in two small separate areas of brown color in the extreme northwest and south of the region.

Soil the shoulders of the rivers.

The soils of the river basins appear clearly along both sides of the river.

Gypsum gravel soils are confined to a small area to the west of the area.

Sand dunes that are mobile and can be seen in a very small area.

The soil in the area was formed as a result of the effect of river floods, as the water was loaded with soil particles (sand, silt, and clay). As a result of the speed of water during floods, its ability to carry the largest amount of it increases, and therefore it flows on the sides of the river, and thus the water loses most of its load in the area and gradually decreases as we move away from the course. Therefore, the clay, silt and sand precipitate, forming the types of soils that were mentioned above.

Fifth: Natural plant:

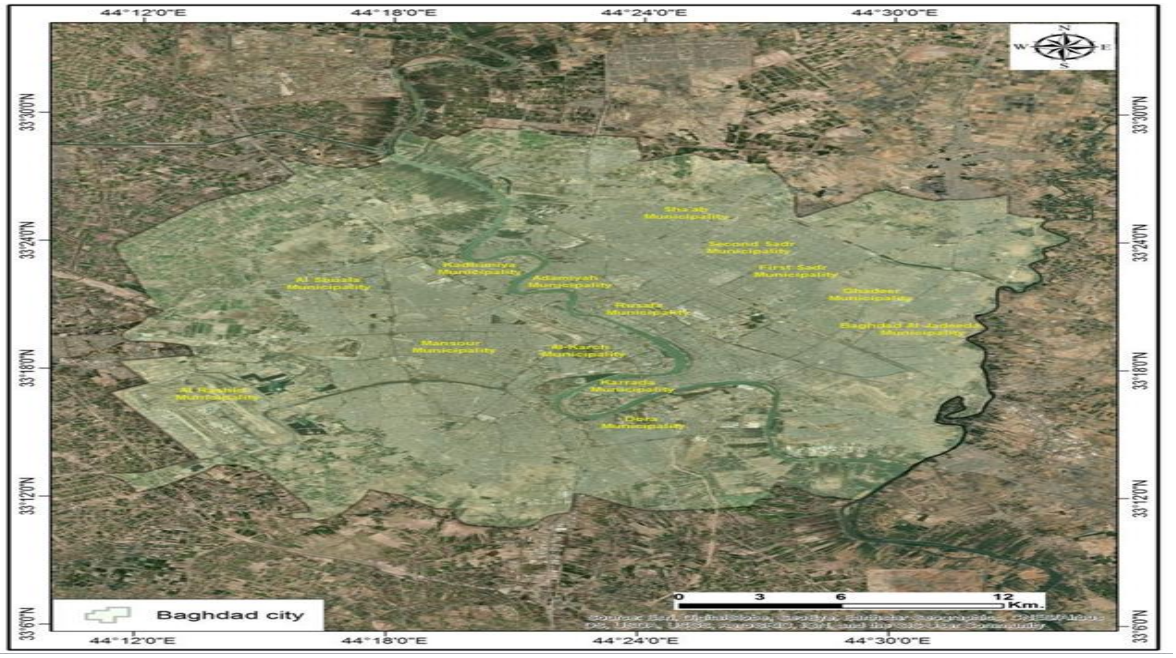
The natural plant grows on its own, and the natural plant and its distribution are affected mainly by the climate, topography, distance and proximity to water sources, as well as the influence of the soil (*Hakkiaraim m.s.c. 1983*). There are many types of natural plants in the region, including thistles, weeds and tadpoles, whose spread indicates a high percentage of salinity as well as the spread of some types of Plants around waterways and on the islands in the Tigris River. These plants have a positive role in reducing water erosion in the region, and the most important of these aquatic plants are (halfa, reeds, and sedge).

Chapter Two: Hydro-geomorphology of the Tigris River in Baghdad

The Tigris River in Baghdad has the characteristic of torsion, meaning that it is one of the crooked rivers that run over wide floodplains and have winding streams. The water supply of the Tigris River is about 48 billion m3 of water, Iraq's share of which is 66%, meaning that the Tigris River has more water than the Euphrates River, and the water flows of the Tigris vary. River due to the amount of water releases from dams and reservoirs available on it.

Hydrology of the Tigris River:

The Tigris River originates in southeastern Turkey, and when it enters the Iraqi territory, 5 tributaries flow into it (Khabur, the Upper Zab, the Lower Zab, the Great, and Diyala). Tigris River in the city of Baghdad is about 5 km before the island of Baghdad and ends with 3 km to the south of the Diyala River. The length of the Tigris River in Baghdad is about (141.19) km, but the width varies from one region to another. It has many islands and twists as shown in satellite image (1) and (2).



Satellite image (1) of Baghdad.

River bends:

It can be defined as a type of river channel patterns, which it passes through in the stages of maturity and aging, with a moderate slope, and the sides of the watercourse are made of fine sediments. Of (mud and silt) coherent and bottom sediments of incoherent sediments of sand and gravel and the stream is considered a bend as the actual length of the stream on the straight length increased by (1.5 times) (*Abdullah, Azza, 1998. p. 400.*) The depth of the river turns increases to increase the vertical sculpting of the sides of the bottom and forms steep edges offset by convex sides The phenomenon of pointpars is formed for us. When the speed of the river's flow drops to a stage where the river sculpting is transformed by the sedimentation process, and some of these sediments turn into barriers dividing the stream whose shape changes to seasonal or permanent islands such as (Baghdad Tourist Island and weddings).

As there is a relationship between water drainage and torsion capacity, as the water drainage increases, the curvature and curvature of the torsion increases. When the ability of the river to erode its bottom decreases, it gradually works to erode its sides. The role played by the running water exceeds the influence of any other factor, as it is noted in table no (2) that the third level, which is located above the bottom, at a distance of (1 m) for all the turns. The velocity of the current in it is shown for the bends (Al-Grayat, Al-Kadhimiya, Al-Adhamiya, Al-Utifi) (15cm/sec) while it is at the top of the Medical City bend (20cm/sec). It can be seen that this current is heading towards a deepening of the stream at the top of the Medical City bend. Therefore, we find that the deepest point is at the bottom of this bend.

These bends vary in size and shape for several reasons:

- The length of the watercourse (river).
- view of the watercourse.
- The strength of the river's current and the nature of its slope.
- The system of evolution of the stream and the stages of growth it went through.
- The nature and quality of materials constituting the bottoms of watercourses.
- The effect of river tributaries and the additional amounts of water they may bring from water and sediments may change the river system.
- The river's transition from vertical activity to horizontal activity (expansion) and a state of inflection occurs.
- The occurrence of slips and the fall of accumulations from the bank into the stream.

Table No. 2 *Tigris River course in Baghdad city.*

The Curve	Measuring Level	Depth Of the Level Below the Surface of The Water (M)	Level Depth Above Sea Level (M)	Speed Of Currents Cm/Sec	Stream Width Within Current Range (M)	Unaffected Duct Width and Position (M)
The Top of The Al-Grayat Bend	Level One Second Level The Third Level	2 Average Depth/9 1m Above the Bottom/19	32,40 25,40 15,40	45 38 15	187,5 112,5 45,00	62.5 On the Left Bank
The Top of The Kadhimiya Bend	Level One Second Level The Third Level	2 Average Depth/4 1m Above Bottom/7	31,21 29,21 26,21	35 30 15	162,5 100 50	32 Ont the Right Bank
Adhamiya Bend	Level One Second Level The Third Level	2 Average Depth/9.5m 1m Above the Bottom/18m	31,9 24,4 14,9	35 25 15	150 120 15	67 On the Left Bank
Peak Utafiya Bend	Level One Second Level The Third Level	2 Average Depth/10m 1m Above the Bottom/19m	32,8 24,8 15,8	35 25 15	100 75 15	72.5 On the Right Bank
The Top of The Medical City Bend	Level One Second LevelThe Third Level	2 Average Depth/10.5 1M Above The Bottom/20.5	32,09 23,59 13,59	38 25 20	150 75 5	54 On the Left Bank

Source: Al-Sharifi, Asma Khazal Abdul-Ridha, Geomorphological characteristics of the Tigris

River course between Al-Muthanna Bridge and Al-Jadriya Bridge and its impact on human use, University of Baghdad, College of Education ibn Rushd, PhD thesis, unpublished, 2007, p. 121.

The effect of water movement in the formation of the river bends depends downward as well as its opposition to another force, which is the force of friction with the bottom and sides. As for the properties of the materials that make up the banks, their effect is through the variation in the strength of their cohesion and it consists of sand, clay and silt, and the proportion of sand increases over the other ratios.

Satellite image *(2*) Twisting of the Tigris River

The degree of impact of water varies with its speed and degree of influence in the processes of induction on both sides of the river according to the proportions of the components of the bank, meaning that it is weak in resistance to erosion and erosion by water, which in turn leads to the discrepancy in the degree of deviation of the stream deviating from the general direction of the Tigris River, forming many turns, as follows:

Al-Grayat bend: deviates from the direction of the Tigris River in a southwesterly direction (87 degrees)

The Kadhimiya bend: It deviates from the course of the river by (85 degrees) in a southwesterly direction.

The Kadhimiya bend: It deviates from the general direction of the Tigris River by (89 degrees) and in a northeast direction.

Utifiah bend: deviates in a northeasterly direction from the Tigris River course (95 degrees).

The bend in the city of medicine: This torsion is less than the rest of the bends, as it is (67 degrees) from the general direction of the river course due to the distance from the

perpendicularity to the general direction of the river course (*Al-Sharifi, Osama Khazal Abdul-Ridha, 2007, p. 36*).

River Islands:

River islands are formed due to river sedimentation processes, as these sediments accumulate at the bottom and gradually rise to the surface of the water. This reflects the state of deficit that the river reaches due to the low speed of the water currents and its weak ability to transfer its load to further areas, so that it is deposited in its place at the bottom or on the side of the bank, which in turn leads to the formation of river islands. Many river islands were formed in Baghdad, including what is shown in visual (3), which shows the island of Doura.

In addition to the existence of another type of islands called side islands as a result of the low speed of the water current in the back of the river torsion or next to it. From Table No (3), which shows the measurements and dimensions of the river islands in the region, we note that the smallest island is the greatest in area if it reaches (2657 m2) and length (87.3). As for the largest island, it is Al-Atifiah Island, with an area of (8340 m) and a length of (213,5 m).

Satellite image (3*)* Dora Island

These islands, despite their small size, will grow quickly due to the large load that the Tigris River brings annually, as well as the different levels, low in summer and high in winter.

Population:

The construction process next to the river and the resulting compaction and merging of soil components cause a decrease in its area and the formation of a solid mass that the watercourse cannot sculpt, while it is active in the neighboring areas due to the weak formation in them. The sedimentation is due to these materials, in addition to the activity of the erosion wheel. The accumulation of sediments in quantities leads to the appearance of a river tongue, such as the tongue at the front of the Curiat bend, as well as the site overlooking the City of Medicine, because of what it received from sewage and hospital waste, which led to the

exposure of the river bank to Erosion and one of the most important reasons for these tongues, which were formed in the form of a tape adjacent to the banks in a longitudinal way, is represented by the low water level due to the lack of drainage, the low rate of gradient and the weak speed of the water currents near the banks, as well as the influence of human factors represented in the presence of a drainage channel (sewage) flowing into the river and the effect of river navigation Which causes transverse waves in the Adhamiya Corniche area, near Al-Shuhada Bridge, near Al-Sinak Bridge, and before the entrance to the Jadiriyah bend (Abdul Hamid Ahmed, 1985; Agrawal et al., 2020; Anand et al., 2021; Arjuna et al., 2020).

Table No. (3) *The most important islands in the Tigris River within the city of Baghdad*

The Island	Area (M2)	Length (M)	Position	Shape
Kadhimiya	81094,13	1022,70	Kadhimiya Bend	Linear
Adhamiya	2657	87, P	Adhamiya Bend	Linear
Atatia	8340	213, Kh	Atomic Bend	Linear
Abu Nawas(1)	27209,66	335	1500m Before the Entrance to the Jadiriyah Turn	Linear
Abu Nawas(2)	17170,27	313.67	South of the Front of The Island (1) At 300 M	Linear
Abu Nawas (3)	12481,39	327,67	South of the Front of the Island (2) At 300 M	Linear

In addition, the effect of the liquid waste of industrial units on the sewage networks leads to the pollution of the Tigris River water, as these networks transport large quantities of waste, in addition to the industrial waste, which is represented by:

- ❖ Medical City in Baghdad.
- ❖ Rustamiya in the Diyala River.
- ❖ Kadhimiya in the middle of Baghdad Governorate.
- ❖ Highway bridge in Jadiriyah, south of Baghdad Governorate.
- ❖ Wastewater and industrial water drained from the city of Baquba.
- ❖ Effect of the following water on the bulges of the Army Canal.

After completing the research and collecting relevant information and using it using the Gis to prepare maps and tables, it proves to us that the research hypothesis is incomplete, that (Tigris River water has a clear impact on the formation of river bends.

This hypothesis was one of the reasons for the formation of river bends, and not the only reason. A group of factors combined besides the characteristics of water currents and their impact on the formation of the bend, which were mentioned in detail, including the characteristics of the materials of the bank and their susceptibility to sculpting and erosion as well as the impact of population and industrial projects.

Conclusions

After completing this research, we reached a number of conclusions, the most important of which are:

1. Variation in climatic conditions with all its components has a clear impact on the variation of physical and chemical weathering processes on the components of the river.
2. The geological situation that the river passes through has a major role in shaping the river bends, as it has become a station for the discharge of various river sediments, being a depression formed due to torsional movements.
3. Most of its components on the surface of the region are from flooded river sediments during

periods of floods, and they are divided into old sediments and modern sediments.
4. The waters of the Tigris River have a key and effective role in shaping the river bends, along with the components of the banks, their characteristics, and their ability to sculpt and erode.
5. Man plays an important role with his various activities in the water in the solidification of the area adjacent to the river and leads to the formation of areas that differ in the degree of their solidity and the degree of erosion, and thus the formation of bends and river tongues.

Suggestions

The most important recommendations we have reached are the following:
1. Obliging the Baghdad Sewage Department to take measures to limit the pollution of river water through sewage and hospital wastes adjacent to the river and enact laws against throwing waste from various sectors (agricultural - industrial - residential) in the river water.
2. Adopting the Gis technique in following up the status of the Tigris River and conducting periodic studies on it in this field to monitor the degree of expansion in the river bends and the formation of islands.
3. Establishment of water treatment units, which require purification before use.
4. Conducting studies on the role of man as an important factor in shaping the river bends through his activities in the various sectors near the banks of rivers in cooperation with the concerned government agencies.
5. The necessity of deploying a concrete dam in a lake with a large water capacity to benefit from it by increasing water releases during the summer period to maintain the water level in the stream and avoid the damages of its decline.

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