A study of the Hydraulic properties of the Shatt al-Arab by the Influence of tidal Movement and Feeding of the Tigris River

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Abstract

This study was conducted to diagnose the effect of variables in the movement of tides and the amount of water released from the Tigris River on some hydraulic properties in the course of the Shatt al-Arab, four stations were selected for the study, namely Al-Sada Al-Noor station, the paper factory, Al-Ashar, and Sehan, and included a measurement, which are the cross-sectional area, discharge volume, net discharge, and water levels. According to the tidal movement located within the lunar calendar for the months of Jumadi Al-Akhir, Rajab, Shaaban, and Shawwal for the year 1443 AH, corresponding to the months from January to June 2022, and for a full tidal cycle (13 hours). The results showed that there is a variation in the cross sections between the studied stations in terms of the shape of the section and depths, and there is a spatial variation in the levels of the studied stations and the variation of the daily and monthly tide range spatially and temporally and according to the studied stations and measurement periods in terms of being the period of flood tide or neap tide, as we note the height of this range in the southern part of the river. The water discharges of the tides varied spatially and temporally according to the stations and these discharges increase as we head towards the mouth of the river, and increase in periods of flood tide for periods of the tide, as for the net daily and monthly discharge, it decreased in the paper factory station from the station of Al-Sada Al-Nour by approximately 10 $m^3 sec^{-1}$ to represent the water consumption of the area between the two stations.

Keywords: Attribution, discharge, net discharge, tide.

Introduction

The Shatt al-Arab River begins at the confluence of the Tigris, and the Euphrates and represents the final stage of the system of these two rivers in the city of Qurna in southern Iraq, approximately 70 km north of Basra Governorate, and the Shatt al-Arab River cuts the governorate towards the southeast (13). It flows into the Gulf of Arab 11 km south of the city of Faw, and the total length of the Shatt al-Arab is about 200 km and formed a common international border between Iraq and Iran for about 91 km of the Shatt Al-Arab River, and the width of the river ranges between 300 m at the city of Qurna and 1000 m at the mouth of the river, and that the depths of the riverbed irregular distribution, the depths ranged from 6 m to 18 m at the maximum depth, (20). The Shatt al-Arab River is considered a tidal river, as it is affected by the phenomenon of tides, and the tidal system is of the mixed type between the half-daily tide and the daily tide, and the prevailing type is the half-daily tide, meaning that there are two floods and two ebbs for one day, unequal in terms of the period and tide ranges, and the tidal cycle may reach 24 hours and 50 minutes,(2). Al-Mahmoud, (21) said that the hydrological characteristics of the Shatt al-Arab are affected by the hydrological conditions of the upper basins of the Tigris and Euphrates rivers and the tidal phenomenon of the Arabian Gulf, as well as the impact of climatic conditions that prevail in the region in the rates of its discharge, as there is no regularity in the arrival of water in quantity and quality to govern the conditions of rain. And underground recharge from the Tigris and Euphrates rivers and the marsh waters emerging from them to the Shatt al-Arab, the hydrological, physical, and chemical specifications are affected. The water of the Shatt Al-Arab is due to the quality of the water coming from the tributaries that flow into it according to the conditions of feeding and storage above the river basin and the amount of water coming out of the southern marshes that flow into it through the Suwaib River. The period of the tides is affected by the influence of the weather conditions prevailing in the region, especially the speed and direction of the winds, as well as the movement of the moon and the resulting tide phases, as there are two phases for each of the spring tide and the tide (Neap tide) during the month of one moon, (9). The course of the Shatt Al-Arab is affected by the phenomenon of tides by the waters of the Arabian Gulf, whose incursion along the course of the river reaches 240 km, and the waters of the Gulf contribute 57% of the amount of running water in the Shatt Al-Arab, (6). Hussein et al., (18). There is a variation in the extent of the tide along the course of the Shatt al-Arab River, as this range reached approximately 1 m in the stronghold area so that the range rises as we head south towards the mouth of the river to reach 3 m in the Faw area, and the wave capacity in the Qurna district reaches 50 cm, and the high ranges have caused a strong current that often exceeds 0.5 m. The speed varies along the course of the channel, as the speed increases and in general at the middle of the channel, and for a decrease in the effect of frictional forces that decrease in the case of cross sections, the efficiency of the stream at the middle generally increases due to the increasing energy of the watercourse and its ability to transport sedimentations, while the speed of the current decreases at the banks (23). Hamza, (16).Show The speed of the moving currents in the Shatt al-Arab ranged between 1 – 1.5 m sec^{-1}, but it takes a decrease in its range as we

head north towards the upper river according to the decrease in the impact of the phenomenon of tides in the north and that the speed of the ebb currents exceeds the speed of tide currents, and the speed of the ebb currents ranged between 0.2-1.3 m sec^{-1}, while the speed of tide currents ranged between 0.15 – 0.9 m sec^{-1}, and there is a clear effect of wind speed, especially those exceeding 1 m sec^{-1}. The sources of water recharge received by Shatt Al-Arab were subjected to a significant decline after they were contributed by the Suwaib stream from the Iranian Karkha River, and the Karma River on the one that connects the Hammar marsh to Shatt Al-Arab, and only the water coming from the Tigris River remained, which became 100% of the total amount of fresh water in the riverbed, so the decrease in freshwater recharge contributed to the increase in the incursion of the tidal wave into the riverbed, especially the discharge of the Karun River, which represents the water mass that obstructs Tidal wave penetrated the riverbed (5). The shapes and areas of the cross-sections of the river section affect the amount of water passing through it and the analysis of the cross-sections in the study of Hussein, (17), showed that there is a role for subsurface structures to influence the shape of the cross sections, through erosion in the riverbed as in the Al- Deer section of and Nuhran Omar section, as well as the presence of some appearances such as sharp deviations in the course of the river and change in the pattern of the river. Al-Asadi (7). Showed that A minimum of 50 m^3 sec^{-1} is the volume of the proposed discharge in the Shatt al-Arab to ensure the conservation of water with moderate salinity in the river from the Basra station to the Siba station, but during the spring tide phase, which is six days of each lunar month, the volume of this discharge must be increased to 70 m^3 sec^{-1}. Reducing the volume of water supply from Maysan Governorate to less than 50 m^3 sec^{-1} will lead to the progress of the tidal wave of marine water, and thus contribute to raising the salinity of the river water. Abdullah (1), Show During his study of the phenomenon of tides in southern Iraq, which included four stations, namely Basra, Siba, Faw, and the outer bar, the average tide range reached (1.18, 0.74, 1.75, and 1.84) meters for the mentioned stations respectively, and that the difference between the highest tide and the lowest ebb decreases as we head up the river, but this difference in the Siba station seems to be less than what is an attic in Basra, and this is from the effect of placing the river there and the dispersion of wave energy to the Karun river and the river adjacent to the ebb of um al-Rasas from the western side and rivers close to the site.

Materials and methods

Study area

In this study, four stations were selected and distributed along the course of the Shatt al-Arab to conduct hydrological measurements, as the first station is located at the Sayed Ali Al-Nour Bridge south of Qurna, and the second station is in the Hartha area at Saad Bridge, and the third station was at the city center of the Ashar area, while the last station was at the Sehan area near the border post. (Fig. 1 and Table 1) illustrate the locations and updates of the stations. Work was carried out in the stations for each station one month on the Arab calendar and extended to the months of Jumadi Al-Akhir, Rajab, Shaaban, and Shawwal for the year 1443 AH, corresponding to the period from January to June of 2022. As Al-Ashar station was studied during the month of Rajab for the

year 1443 AH, and the stations of Al-Sada Al-Noor and the paper factory were studied simultaneously during the month of Shaaban for the same year. As for the Sehan station, it was studied during the month of Shawwal of the same year.

The climate of the study area

The prevailing climate in the study area is characterized by being a semi-tropical continental climate, as can be observed in the prevalence of two seasons mainly, namely the winter season and the summer season, and despite the small amount of rain falling in this region. but its fall is concentrated during the winter, and the summer season was characterized by high temperatures that exceed 50 c^0 on some days, especially in July and August, that the prevailing winds in the region are the north and northwest winds (19).

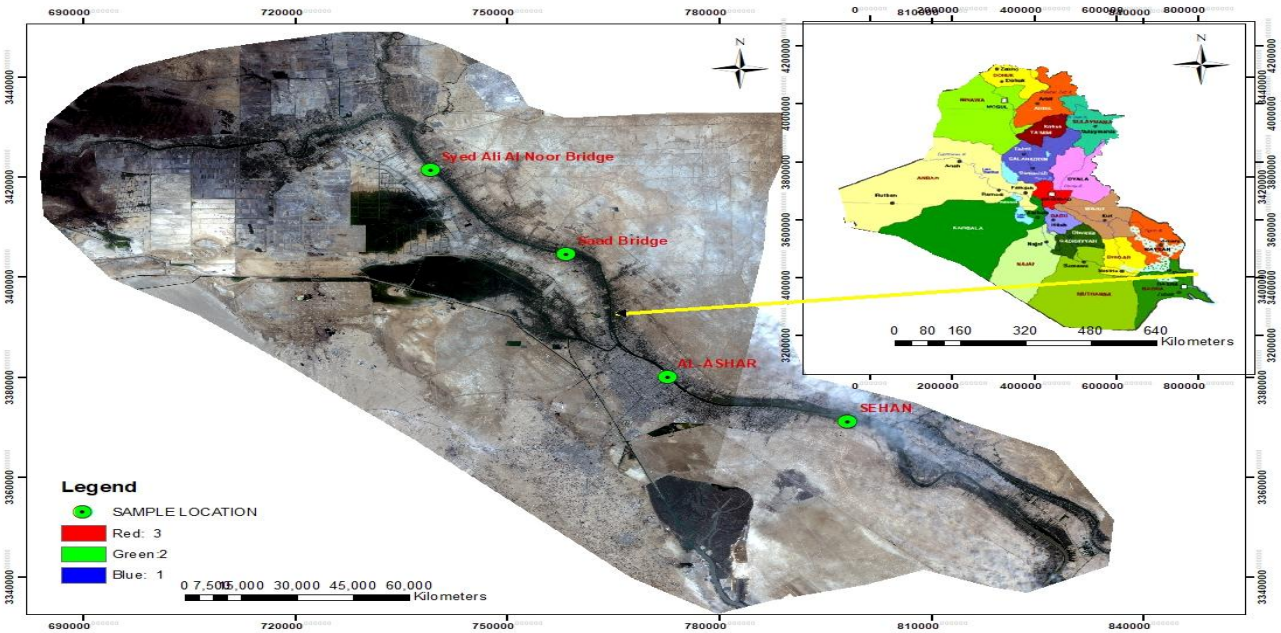
Field measurements

Measuring the cross-section of the river**:** The Simpsons rule method was used after dividing the section into three approximately equal sections using an iron weight linked to a strong rope and marked with a tape measure through which the depth can be known after the weight is lowered and settled at the bottom, and the equation below is applied:

cross-sectional area = (section length / 3)} (first depth + last depth) +2 (sum of odd depths) +4 (sum of even depths)) (24).

Table 1. The coordinates of the locations of the measurement stations.

Sq.	stations	Longitude	Latitude
1	Sayed Ali Al-Noor Bridge	$47^0$29'56.66'E	$30^0$54'6.52'N
2	Saad Bridge	$47^0$42'3.58'E	$30^0$44'41.82'N
3	Al- Ashar	$47^0$5035.01E	$30^0$31'15.49'N
4	Sehan	$48^0$11'42.69'E	$30^0$19'35.70'



Map 1. Study station locations

Level measurement

The river water level was measured up and down during a full tidal cycle at all stations at the same time and on the same days (for the same month) by determining a fixed point at each station and measuring the water level of that point relative to reference point B. M.

Measuring the speed of current

The speed of flow in the channel or stream exceeds the rate of flow velocity, so the rate of flow speed is extracted by multiplying the surface speed by a correction factor related to the degree of roughness, the shape of the channel, and the depth of flow, and its value ranges between 0.8 and 0.9, i.e. at a rate of 0.85 and as in the equation below:

Flow velocity rate = measured surface velocity * Correction coefficient ... (11). To calculate the discharge in this way, the cross-sectional area is multiplied by the rate of flow velocity.

Discharge measurement

The discharge was measured by adopting the following equation for each hour of the tidal cycle (21):

$$Q_1 = A_1 V_1$$

where: - Q_1 - Water discharge of the first section in the first hour of the tidal round.

A_1- First cross-sectional area

V_1- The current speed in the tidal cycle's first hour.

Then the discharge of the tide hours and the expenses of the ebb hours are collected separately, and the discharge through the cross section is the sum of the discharges in the three sections, and the net discharge of fresh water in the cross section is the difference between the sum of the discharge of the ebb hours and the sum of the discharge of the tide hours, (7).

Results and discussion

Cross-sectional area

Figures (1, 2, 3, 4) show the cross-sections of the study stations, Al-Sayed, Al-Nour, the paper factory, Al-Ashar, and Sehan respectively, as the shapes of these cross-sections vary spatially along the course of the Shatt Al-Arab, and it is noted that there is a difference in the width of the river as well as in the depths of the river between the studied stations, as the depths of the river increase as we head south towards the mouth of the river and ranged according to the studied stations from 8-14.5 m, as the variation in the depths of the river bed During these years, due to the lack of river discharge and thus the river became unable to carry sediment over long distances, the discharge of the river decreased from 300 m^3 sec^{-1} in 1990 to 50 m^3 sec^{-1} in 2006 (12). Depths decrease when a sedimentation process occurs, which occurs as a result of a decrease in the speed of the current to less than the sedimentation speed of the sedimentary minutes moving with the current of the running river. (4).

The shapes of the cross sections of the river are affected by tidal currents that helped in the emergence of their natural forms through erosion and erosion, and through the influence of waves, which is determined by the nature of the prevailing winds in the region, as the northwest winds are the prevailing winds in the region, followed by the southeast winds, which are the most influential because of the high waves they cause in the mouth of the river and the southern part of the river, as well

as the impact of the movement of ships and boats in the work of waves that are effective in erosion, and less The effect of these winds gradually decreases in intensity and height as we head towards the upper river, so we find that the section of the river is wider and deeper than in the northern part of the river (22).

Level

Figure 5-A shows the levels of the Shatt al-Arab water in the station of Al-Sada Al-Noor, we note that there is a daily variation in levels and that the highest level in this station was 2.09 m and the lowest level reached 1.21 m and the range of 0.88 m and this happens on days of the flood tide, while the tide decreased to 0.55 m on the days of the tide as the highest level on the twenty-third day reached 1.98 m, while the lowest level reached 1.43 m for the same day, and when moving to the paper factory station, which was studied in conjunction with the Sada Al-Noor station, we find that the tide range is 0.7 m, as the highest level of 1.8 m was swallowed, while the lowest level reached 1.1 m in the case of the flood tide, and in the case of the tide, the range decreases to 0.52 m, as it reached the highest and lowest levels of 1.7 and 1.18 m, respectively, Figure 5-B. The decrease in levels is generally due to the lack of water revenues of the Shatt al-Arab on the one hand and the distance of these two

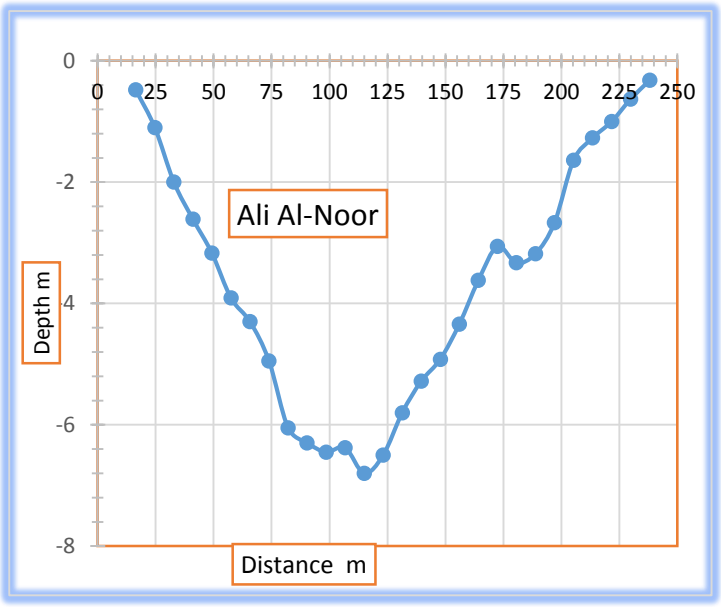


Figure 1. Al-Sada Al-Noor section.

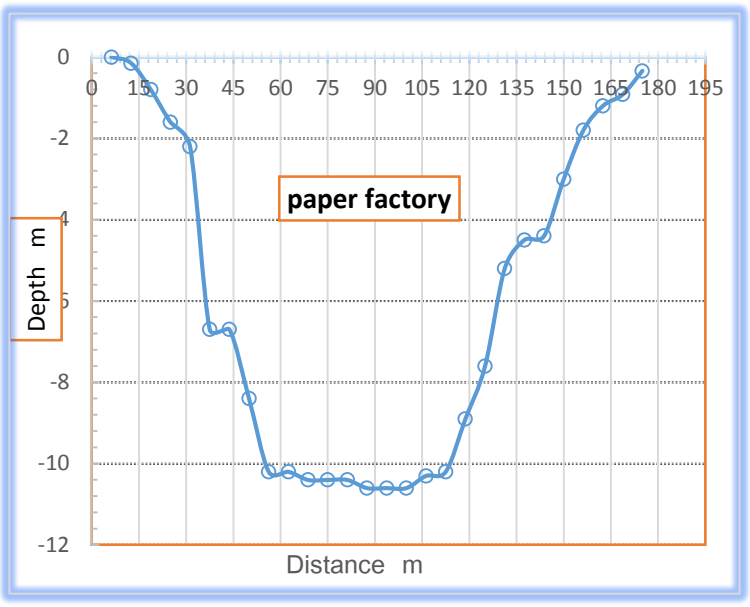


Figure 2. Paper Factory section .

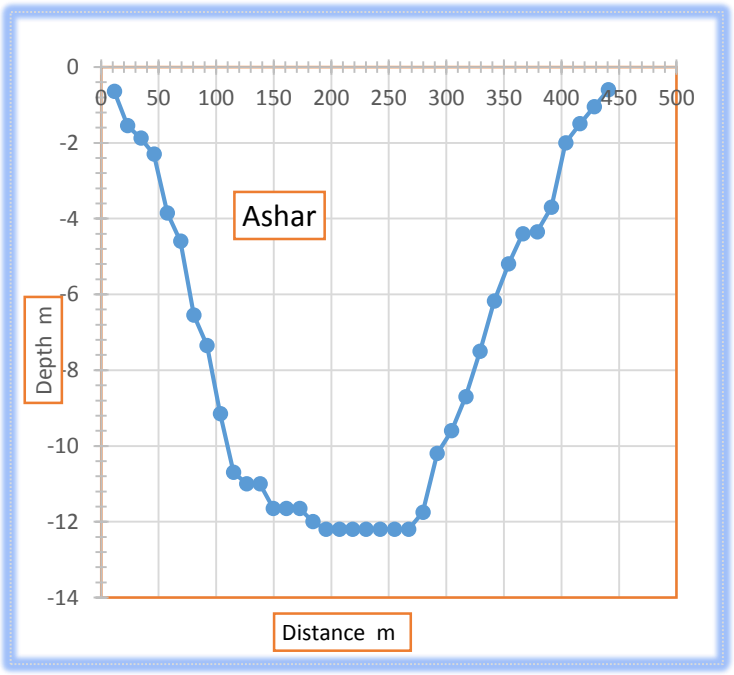


Figure 3. Al-Ashar section.

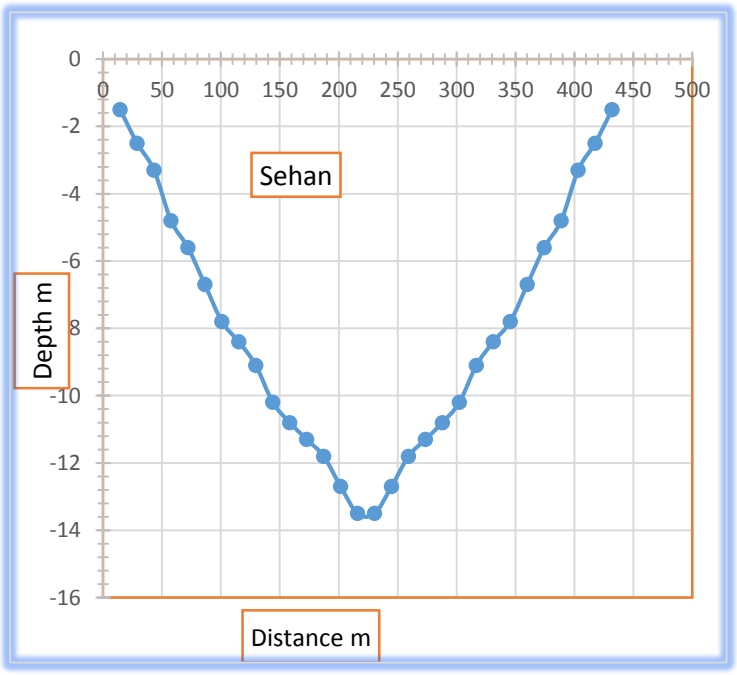


Figure 4. Sehan section.

stations from the mouth of the river and thus the lack of influence of tidal currents on them on the other hand, which led to the difference in tide ranges between stations (16). When observing the levels of the two stations during the measurement period, which is a month in the Arab calendar by sixteen days, we find that there is a discrepancy between the levels of the two stations, as the highest level for the month reached 2.09 and 1.8 m for the two stations, Al-Sayed Al-Noor, and the paper factory, respectively, and the lowest level during the measurement period reached

1.21 and 1.1 m for the two stations, respectively, (Figures 6

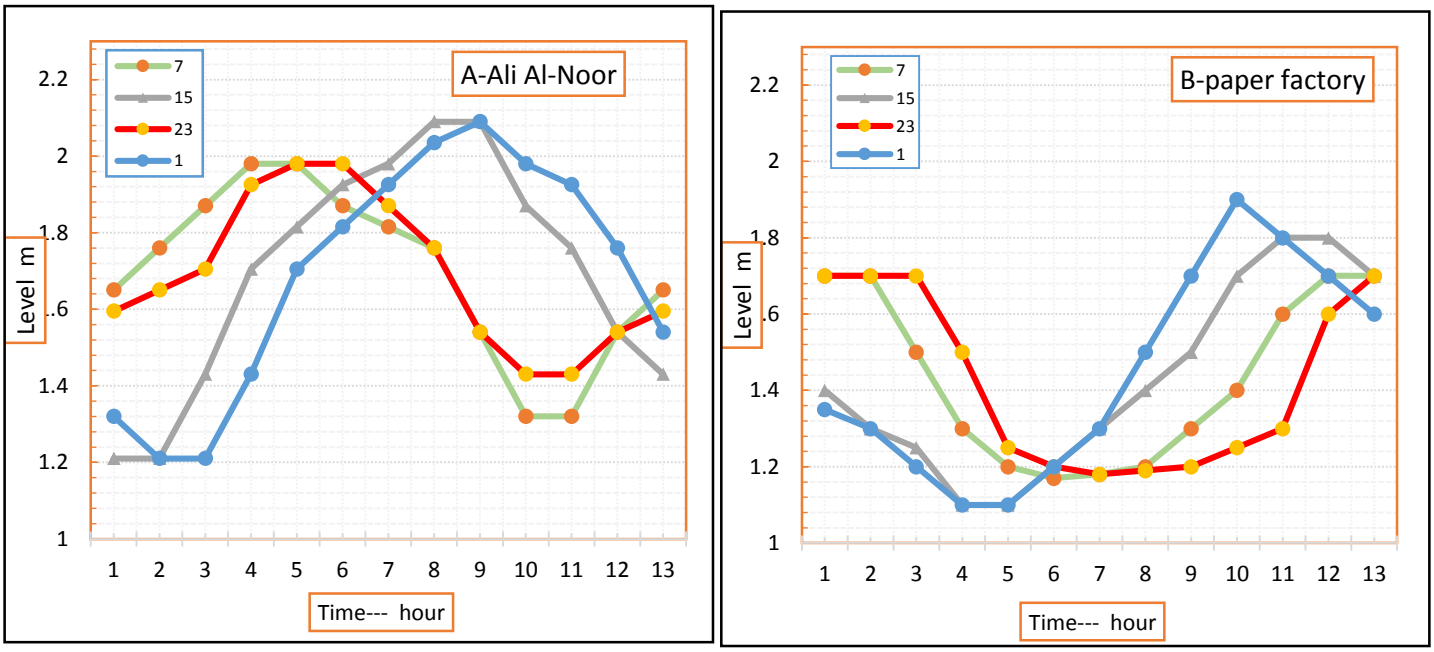


Figure 5. Water levels on neap and flood tide days for Al-Sada Al-Noor station (A) and Paper Mill Station (B).

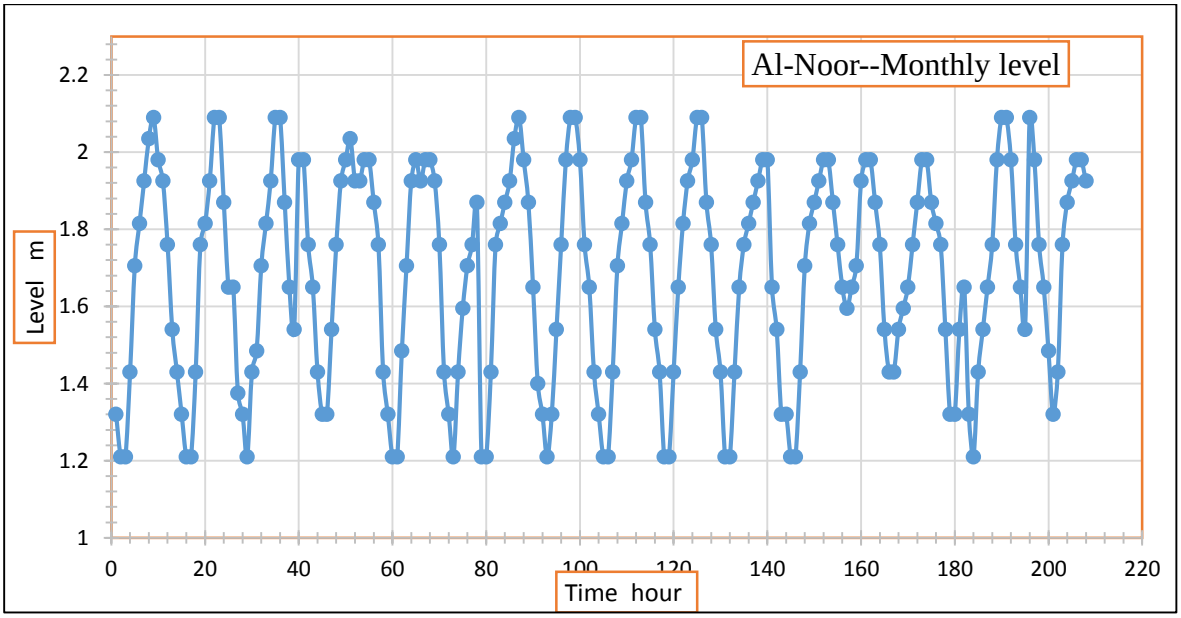


Figure 6. The monthly water level of the Shatt al-Arab at the Al-Sada Al-Noor station.

and 7). It was also found that there is a time discrepancy in the occurrence of peak tide and peak ebb between the stations of Al-Sada and the paper factory, due to The distance between the stations being large and the height of the level of each of them due to the stampede tide and not the rush tide that operates at the southern stations of the river, (8). The levels of the Ashar station were also studied over a month in

the Arab calendar and by twenty-three days, and Figure 8-A shows that there is a temporal variation in water levels according to the days and their occurrence in the period of flood tide or tide, as the highest tide level during the period of the tidal cycle studied reached 1.61 m, while the lowest level of ebb reached 0.42 m, and from this, we conclude that the highest tide range is 1.19 m, and this happens at the beginning

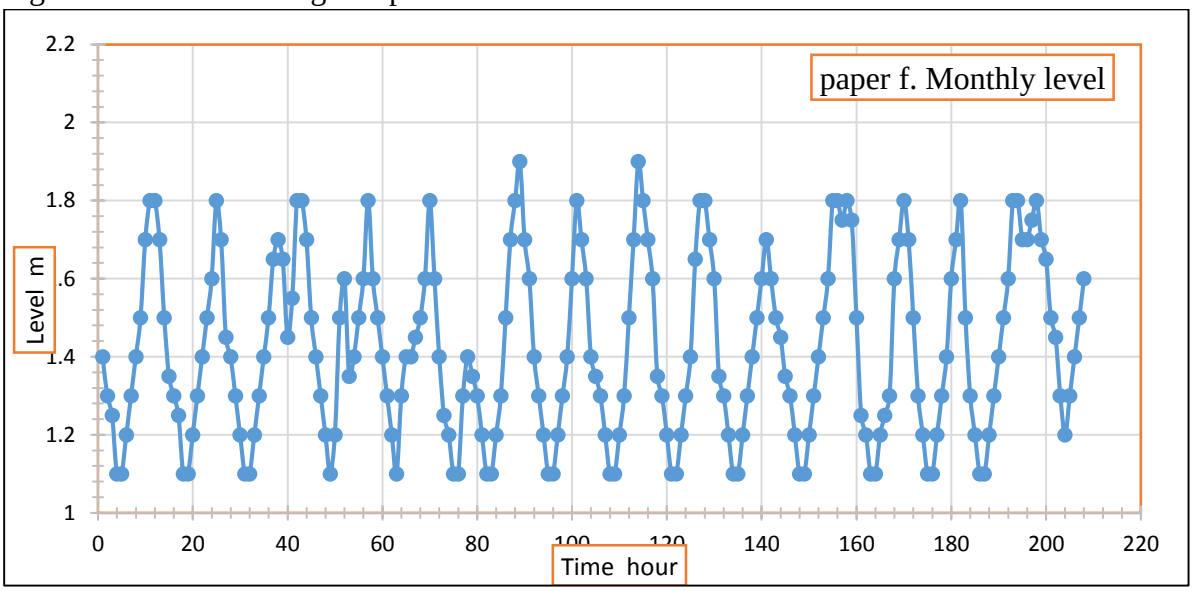


Figure 7. Monthly water level of the Shatt al-Arab at the paper Factory station.

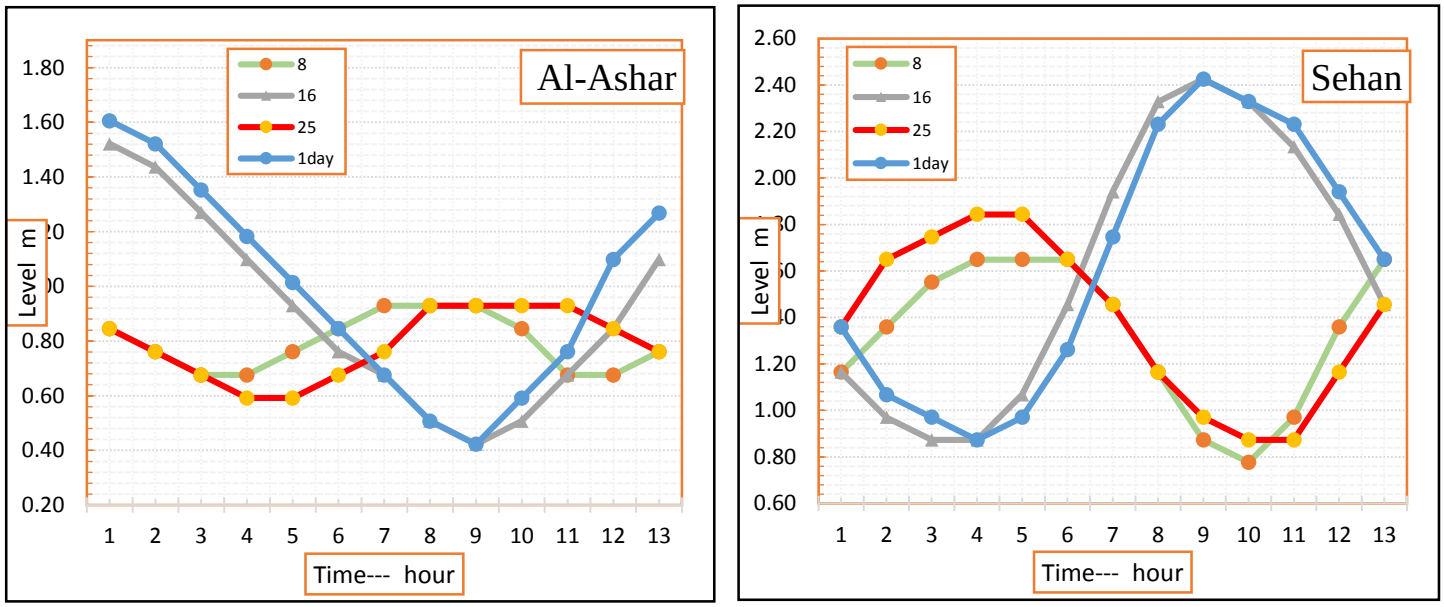


Figure 8. Water levels for neap and flood tide days at Al-Ashar (A) and Sehan (B) stations.

of the first week of The Arab month, that is, during the period of the flood tide, while the highest level of the tide in the in the extent of the tide is due to the amount of water entering the tide state

tide period and 0.68 m, respectively, and this variation

during the flood tide period, which is greater than the amount of water entering

the period of the tide, and the tidal tide increases as we head towards the mouth of the river (15).When advancing towards the south, where the Sehan station is, we find that there is a temporal variation (daily) between water levels, as the highest daily level of the tide reached 2.43 m, while the lowest level of the ebbs for the same day was 0.87 m, and this was recorded at the beginning of the Arab month and was also repeated in the middle of the month (flood tide period), and thus the largest daily range of the tide is 1.56 m, but the levels recorded a decrease in the period of the tide, as the highest daily level reached 1.84 m and reached the lowest The daily level of the same day is 0.87 m, and the daily tide range during this day is 0.97 m, while the lowest daily tide range is 0.87 m, which resulted from the highest and lowest tide of the eighth day of the Arab month, amounting to 1.65 and 0.78 m, respectively, (Figure, 8-B). This variation in water levels is due to the variation in the intensity and duration of tidal currents during the tidal cycle of one day, as it results in high tides and low tides, as well as the case for the ebb, and the associated amount of water entering or the amount of water returning or discharged from the riverbed, according to which the water level changes, (12).

Figures 9 and 10 show the monthly water levels of the Shatt al-Arab for the two stations of Al-Ashar and Sehan respectively, as we find that there is a discrepancy in the monthly levels, as the monthly tide range reached 1.19 m and 1.65 m for the above stations and respectively, and this is due to two reasons, the first of which is that the fieldwork of the Ashar station took place during January and February, and they are within the period of scarcity or drought extending from September to February, while the fieldwork of the Sehan station took place during May. Within the flood period, the other reason is due to the proximity of Sehan station to the mouth compared to Al-Ashar station and its impact on the tide phenomenon, (14) who explained that

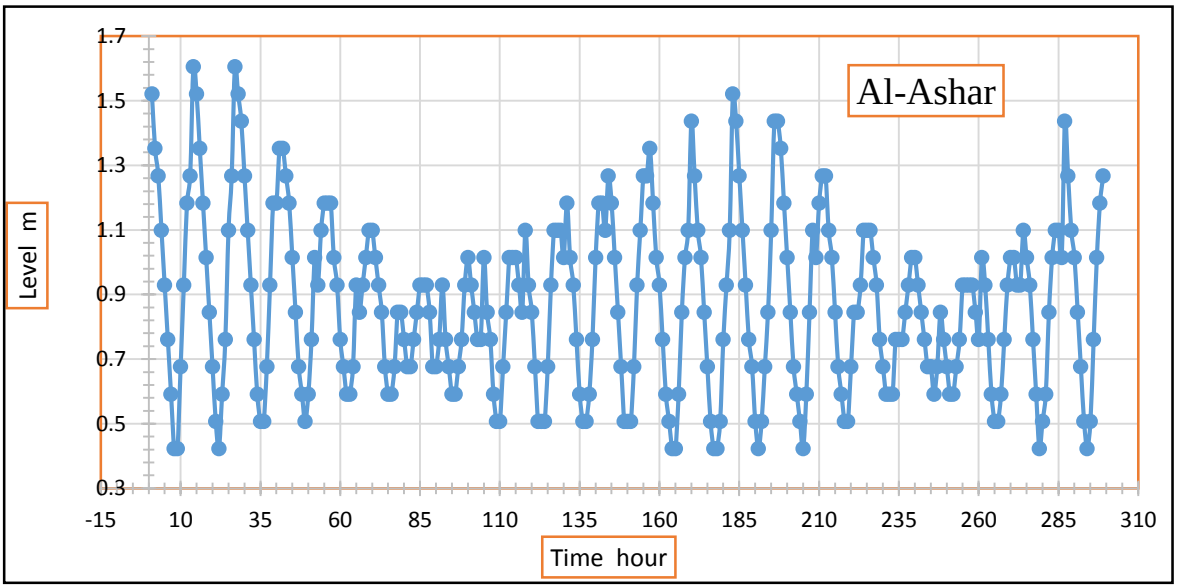


Figure 9. The monthly water level of the Shatt al-Arab at the Ashar station.

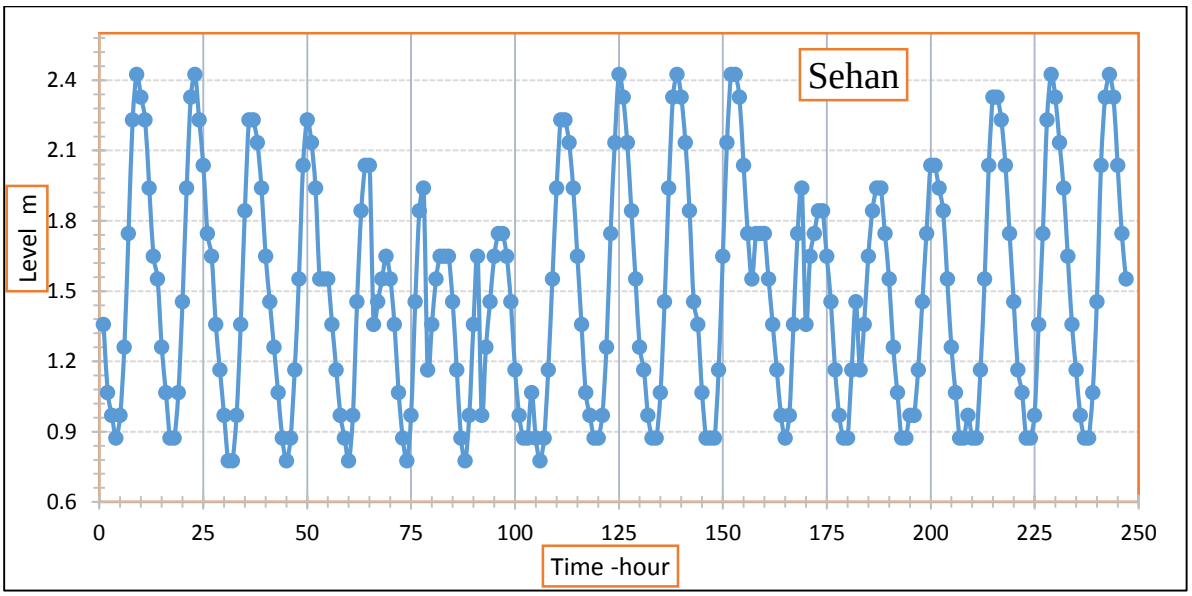


Figure 10. Monthly water level of Shatt Al-Arab at Sehan station.

the water levels in the Shatt al-Arab vary between tides, as the maximum tide range reached 1.5-4.5 m for Basra and Faw respectively during the study period

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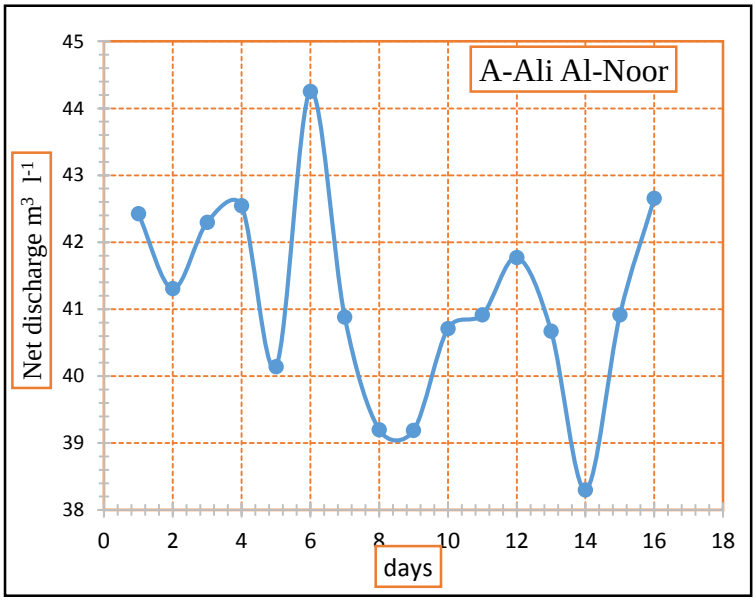
Discharge and Net discharge

The Shatt al-Arab is characterized by instability in the water drainage system, as the quantities of discharge vary spatially and temporally from one station to another and along the course of the Shatt al-Arab and between year and year, but between the months of different tongues, and between the days of one month and depending on the houses of the moon, there is a flood tide, which is the largest as well as the longest time of the second type of tide, which is the tide, and even beyond that, there is a variation during the day, the tide capacity may vary during one day For the presence of a debtor and two ebbs, there is a high tide and a low tide, as is the case for the ebb, (1). The discharge was calculated by multiplying the cross-sectional area of the river by the flow speed and for each of the three sections of the cross-section, as the cross-sectional area changes for each hour of the tidal cycle, that is, it changes with the change of the water level according to the movement of the tides. The work was synchronized in the stations of Al-Sada Al-Nour and the paper factory, i.e. at one time, which is the month of Shaaban for the year 1443 AH, and the results showed that the highest discharge of the tide recorded at the station of Al-Sada Al-Nour during the hours of the tidal cycle was -44.82 m ^{3} sec^{-1} (the negative signal means that the direction of the current is opposite to the mouth of the river), and this indicates that this station is affected by the movement of tidal currents coming from the Gulf, as the lack of water revenue for the Shatt al-Arab from the Tigris River allows increasing the tidal energy and penetration Water to distant areas downstream (21). While the highest discharge of the ebb at the same station during the tidal cycle was 135.43 m^3 sec^{-1}, this was recorded in the period of the flood

tide and the volume of discharge decreased highest discharge of tides -31.45 and 112.71 m^3 sec^{-1} respectively, Hence, we find that the discharge of the ebb at this station exceeds the discharge of the tide, and what supports this is that the net daily discharge is a positive value, which ranged between 38.3 - 44.25 m^3 sec^{-1} for the studied period and a monthly average of 41.13 m^3 sec^{-1} (Figure 11A-). At the paper factory station, we find that the highest discharge of the tide amounted to -39.24 m^3 sec^{-1} and was at the beginning of the Hijri month, but the highest discharge of the ebb amounted to 123.30 m^3 sec^{-1} and was recorded in the second flood tide period (mid-month), and at the period of the tide, the volume of discharge decreased to reach a maximum of tides -36.21 and 111.28 m^3sec^{-1} respectively, and as in the previous station, we find that the discharge of the ebbs is higher than the tide discharge at this station as well, the value of the net discharge was The daily and for all days studied are positive and ranged between 29.61-33.37 m^3 sec^{-1} and a monthly average of 31.75 m^3 sec^{-1}, (Figure B -11). When comparing the monthly net in the period of tidal tides to record the discharge of the two stations, we find that there is a decrease in the value of the net discharge, which amounted to 41.13 and 31.75 m^3 sec^{-1} for the above two stations respectively. With a difference of 9.38 m^3 sec^{-1}, this comprises the water consumption of the area between the two stations and includes agricultural, industrial, and human consumption and the number of water losses from leaching and evaporation. As for Al-Ashar station, the work was in conjunction with the Sehan station, carried out by the research team to measure the discharge and levels at Al-Ashar station, while the levels were measured only at Sehan station for the same period (the month of Rajab in 1443 AH), the results showed in Figures (12-A and B) that the discharge gave the highest values at the first days of the month, specifically, the second day, which is within the flood tide period, and reached the highest tide of 697.49 - m^3 sec^{-1} during the studied tidal period, as The highest discharge for the first and third days was -677.10 and -684.45 m^3 sec^{-1} respectively.



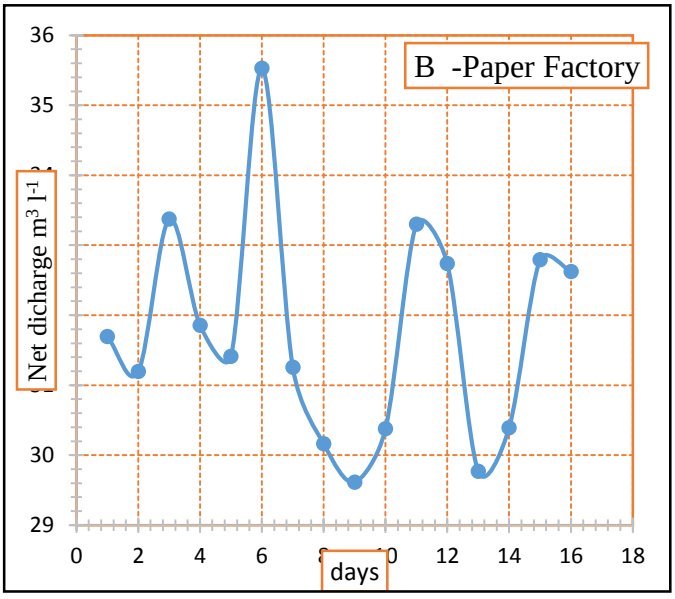


Figure 11. Net daily discharge of the Shatt Al-Arab at Al-Sada Al-Noor A station and paper factory station B.

While the flood reached the highest tide of 697.49 - m^3 sec^{-1} during the studied tidal period, and the highest discharge for the first and third day amounted to -677.10 and -684.45 m^3 sec^{-1} respectively, while the highest discharge during the ebb period for the same period of time was 385.43 m^3 sec^{-1}, and there is another tide period that occurs at the beginning of the third week (mid-month and beyond), as the highest tide discharge reached -623.59 and -621.09 - m^3 sec^{-1}, while the highest discharge of ebbs in the flood tide period The second has reached 360.39 m ^{3} sec^{-1}, and there is a period of tide in which the discharge decreases to 508-520 m^3 sec^{-1} at the beginning of the fourth week and the highest discharge is due at the beginning of the lunar month because this period is considered a period of flood tide in which the discharge is high as well as the presence of a period of tide due to the force of attraction between the earth, the moon and the sun, when the moon is a crescent and this happens at the beginning of the month and in which the moon, the earth and the three sun are on one straight, i.e. In one line, the tidal forces are united by the overlap of forces, and the moon is between the earth and the sun. The second is when the moon is the full moon and the three are on one line, but this time the earth is located between the sun and the moon, that is, there is no union in forces and the tide is less than the first case, and in these two cases the tide is called the spring tide, but in the case of the tide of the erasers, in which the earth and the sun are on one line, but the moon is perpendicular to the earth, which forms a right angle with the earth, and this happens at the beginning of the second week and the beginning of the fourth week of the Arab month and decreases The rise of water due to the dispersion of forces, (3). We also find that there is a discrepancy in the value of the net daily discharge, as it ranges between positive values and negative values, and this depends on the volume of water revenues received from the Tigris River when these revenues increase, the value of the net discharge becomes positive and pushes the impact of tidal currents coming from the Gulf, but when the volume of water revenues decreases, the value of net discharge becomes negative, which indicates the impact of tidal currents at this station. (7).

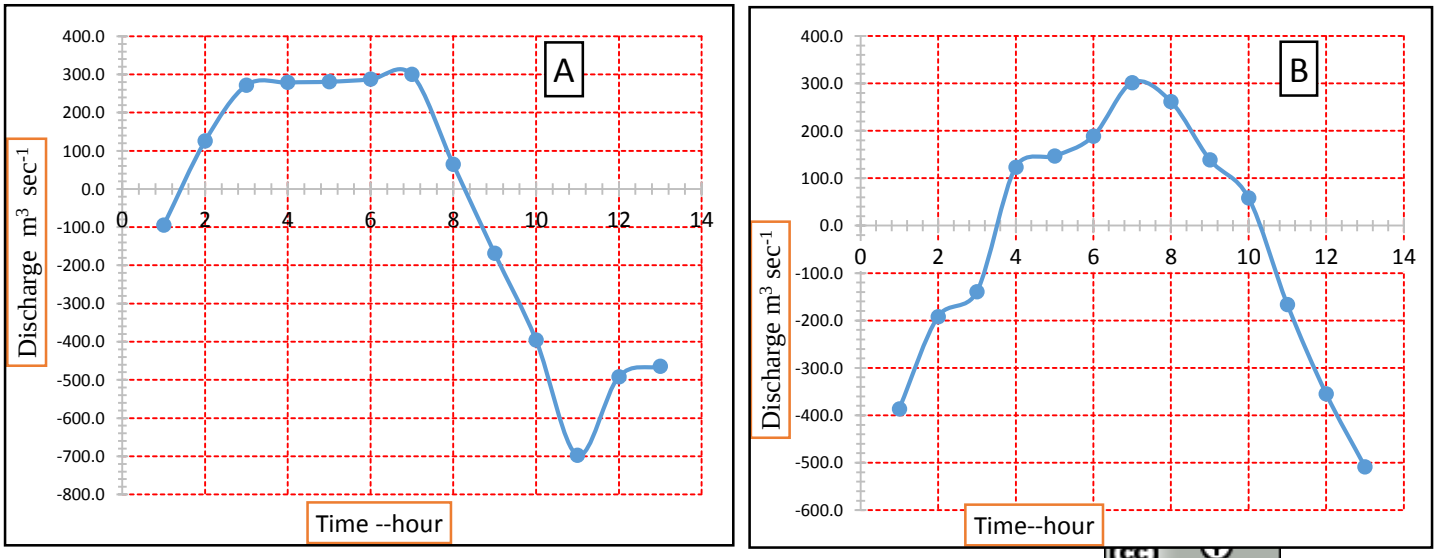


Figure 12. Discharge in flood tide A and neap tide B of the publican station.

This showed that the lower the water revenue from the tributaries feeding the Shatt al-Arab, the greater the impact of tidal currents in the course of the river. Hence, the water consumption of the water coming with the tide, and we notice that the negative values prevail over the positive values of the daily net discharge to obtain a monthly net discharge for the period studied at this station with a negative value of 6.19 m^3 sec^{-1}, (Figure 13-A). At Sehan station, there was a significant increase in the discharge values of the tides, compared to other studied stations, as the highest tide discharge at this station in the flood tide period reached -1773.14 m^3 sec^{-1} and the highest discharge of the ebb amounted to 1102.37 m^3 sec^{-1} at the same station, while the volume of discharge in the tidal period decreased to -1218.56 and 920.99 m^3 sec^{-1} for daily tides respectively, and the results also showed that there is a discrepancy in the values of the net daily discharge as most The values for the days studied have a negative sign, and this indicates the superiority of the tide discharge over the discharge of the ebb at the Sehan station, and the values ranged between -235.44 - 5.04 m^3 sec^{-1} and at a monthly rate of -100 m^3 sec^{-1}, (Figure, 13-B). This is due to the proximity of this station to the mouth of the river and its great impact on the phenomenon of tides, (5).

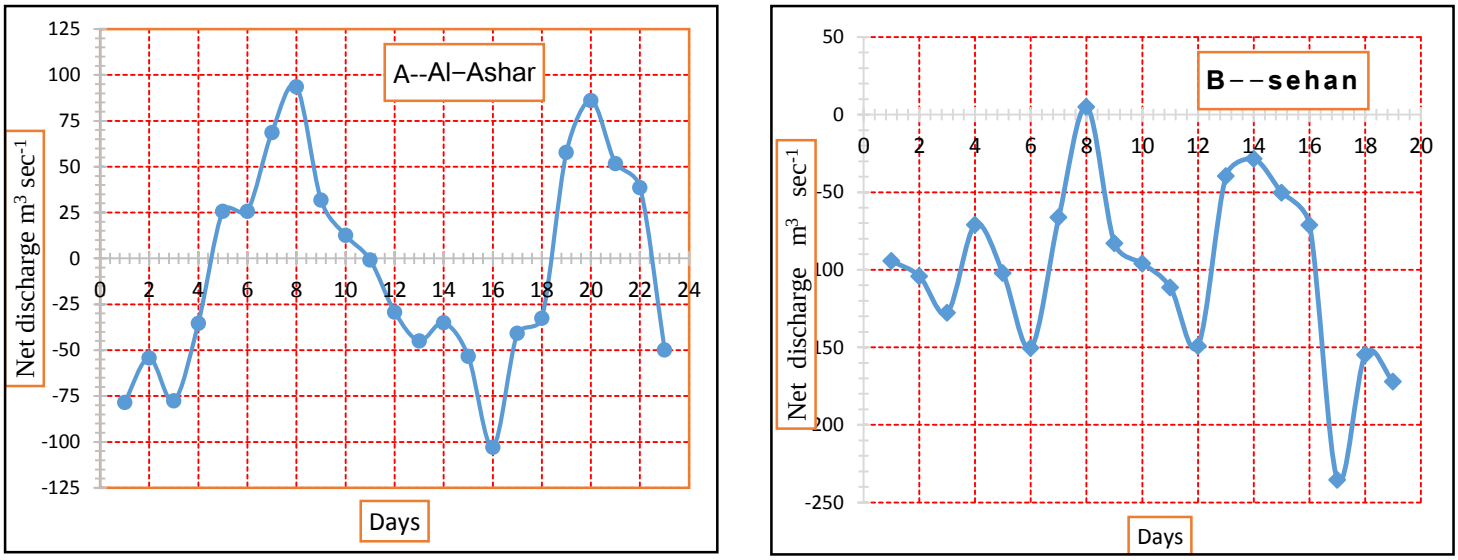


Figure 13. Net discharge for Ashar A station and Sehan B station.

Conclusion

The study included four stations on the course of the Shatt al-Arab to find out the changes in some of the hydraulic properties of the Shatt al-Arab by the effect of tidal movement. The results showed that there is a variation in water levels, discharges and net discharge between stations and seasons studied, depending on the amount of water revenues that reach the river, and this has a major role in the progress or decline of salt tide currents coming from the Gulf, which

may reach large distances in the Shatt al-Arab in the event of a decrease in river discharge, which is what is happening now as this decrease in river discharge led to a decrease in water levels, discharges, and high water salinity.

Conflict of interest

The authors have no conflict of interest.

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