ENGINEERING RESEARCH JOURNAL (ERJ)
Vol. 2, No. 51 April. 2022, pp.148-155
Journal Homepage: erj.bu.edu.eg

Morphological Changes in the Nile River in the Bridges Region

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Abstract

In light of the Nile River's importance to Egypt, this study was started to explore the river's flow and sediment in an analytical manner. The goal of this research is to look into the morphological changes in the Nile River. The Nile River is subjected to erosion and sedimentation at various points due to its natural geomorphology. Within the fourth stretch, it was focused on two regions. Upstream and downstream of the El-Menia bridge were the first. Upstream and downstream of the Bani-Suefbridge were the second. Along the research region, 70 cross-sections from 1982 were compared to 2002. In addition, the same cross-sections from 2002 and 2004 were compared along the same area. During these times, the deposition and scour were calculated. In the first location, erosion happened more frequently than deposition, according to the comparison. In the second area, on the other hand, the comparison revealed that deposition was more common than erosion.

Keywords :Morphology, Hydraulic structure, Scour, AD (Aswan Dam), Dredging Operations.

1. Introduction

Engineers and scientists are always fascinated by rivers' self-formed geometric shapes and their responses to changes in nature and human interference. In addition to engineering, understanding rivers' behavior is also necessary for environmental enhancement, Chang (1988), [1]. People have intervened in the natural course and behavior of rivers since pre-recorded history to manage the water resources, protect themselves against flooding, or make passage easier along or across rivers easier. Likewise, it is the case in Egypt where irresponsible human interventions into rivers (i.e., creating islands and constructing buildings within their boundaries) caused a reduction in the capacity of the Nile River. Starting from the late 20th century, environmental concerns broader than immediate human benefit (i.e. engineering projects) attracted attention exclusively. Restoration or protection of natural characteristics and habitats has become an important issue. The erosion and sedimentation processes in rivers are affected by changes in hydraulic characteristics and human interventions. The construction of Aswan High Dam (AHD) has caused major changes in hydrological characteristics downstream of the dam, consequently affecting the river morphology. Sadek et al. (1999) studied and evaluated the effect of AHD on the morphology of the Rosetta Branch.[10]

Therefore, knowledge of morphology change is important to plan engineering works such as identification of vulnerable areas, installation of hydraulic structures, confinement or widening of river channels, dredging, sand extraction, dam construction, development of setback planning, and hazard zoning, Dinuke (2021) [2]. Sadek N. (2013) studied three alternatives to develop the Shubra El-Khaima Island. The third alternative was considered the best situation where the degradation values for several sections were between zero and 0.2 m [11]. Hekal N. (2008) studied the prediction of the future situation of the River Nile navigational path and concluded that the expected thickest aggradation would be about 17 cm and occur at Geziret El Sheikh Temi, 656 km downstream of Aswan Dam, while the thickest degradation would reach about 15 cm at Abo Aziz, 728 km downstream of Aswan Dam [12]. Hekal N. (2018) showed the morphological change rates over the period between the years 1982 and 2004 in three discharge cases (low, medium, and high) at reach four. It was concluded that the equilibrium status of a river's reach depended on the released discharges, as every case revealed a different equilibrium status depending on the inclusion or exclusion of the adjacent floodplain areas [3]. Mousaa A. (2010) studied the morphological changes of reach four of the Nile River that is located between Assuit and the delta barrage from 1982 to 2004 by using rating curves analysis and cross-sections comparisons. By comparing cross-sections during the period from 1982 to 2004, he found that there was lowering in water levels at some sections in the upper part of the study area due to degradation and changes in the area of cross-sections and water levels due to aggradation. Also, he found that for different flood scenarios, there were large drops in water levels in the year 2004 than in 1982 due to a huge degradation [5]. Mousaa et Al. (2010), applied GIS to illustrate the morphological changes at the length of 4 km from km 906 to 910 including Aswan Bridge. He showed that there were degradation and deposition at the different positions for the study cross-sections. The study length became shallower and wider in its northern part than it was in the past because of the deposition effect. Also, at the place where the Aswan Bridge was constructed, there was no change in the bank for both sides, but there was a scour around the bridge piers [6]. Meky M. and Zeidan B. (2021) found that hydro-morphological estimation was a key foundation for river management and should be based on the increasing understanding of geomorphological processes. Also, it was noticed that the numerical models supplied the basis for understanding the conditions of hydrodynamic and geomorphic in river ecosystems and were a worthwhile tool for solving complex problems in river and environmental engineering [4].

2. The study area

The study area includes two regions and is located at reach four. The fourth reach stretches from Assuit Barrage, at km 544.750, to Delta Barrage, at km 953.500 from AD, , as shown in Figure 1.The first area was applied at 1.085 km, which extends from km 684.330 upstream of the El-Menia Bridge to km 685.415 downstream of the El-Menia Bridge from AD. The second area was carried out for 3.070 km from km 807.800 upstream of the Bani-Suef Bridge to km 810.870 downstream of the Bani-Suef Bridge from AD. 20 and 50 cross-sections were studied covering the first area and the second area, respectively. El-Menia Bridge was constructed in 1987, and the Bani-Suef Bridge was constructed in 1984 [9].

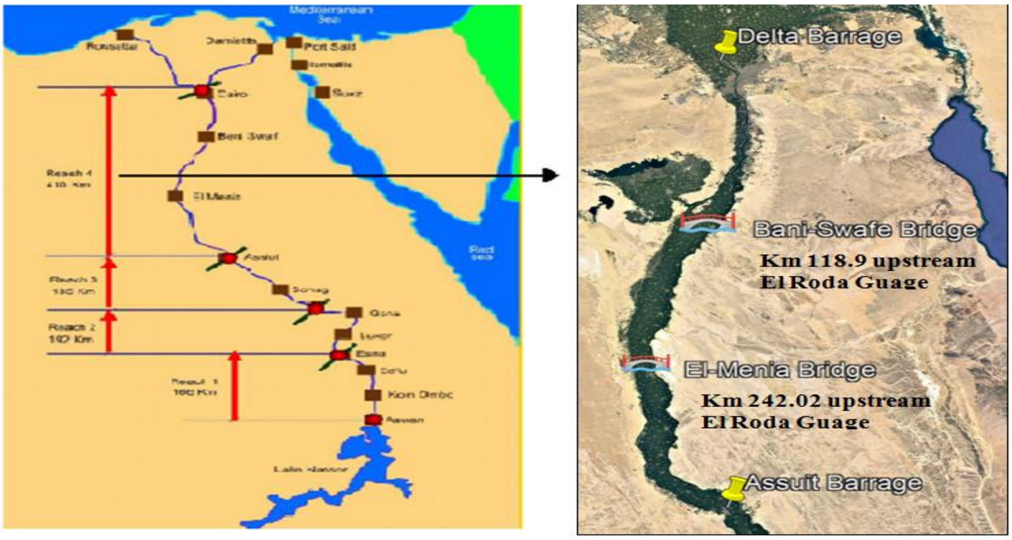
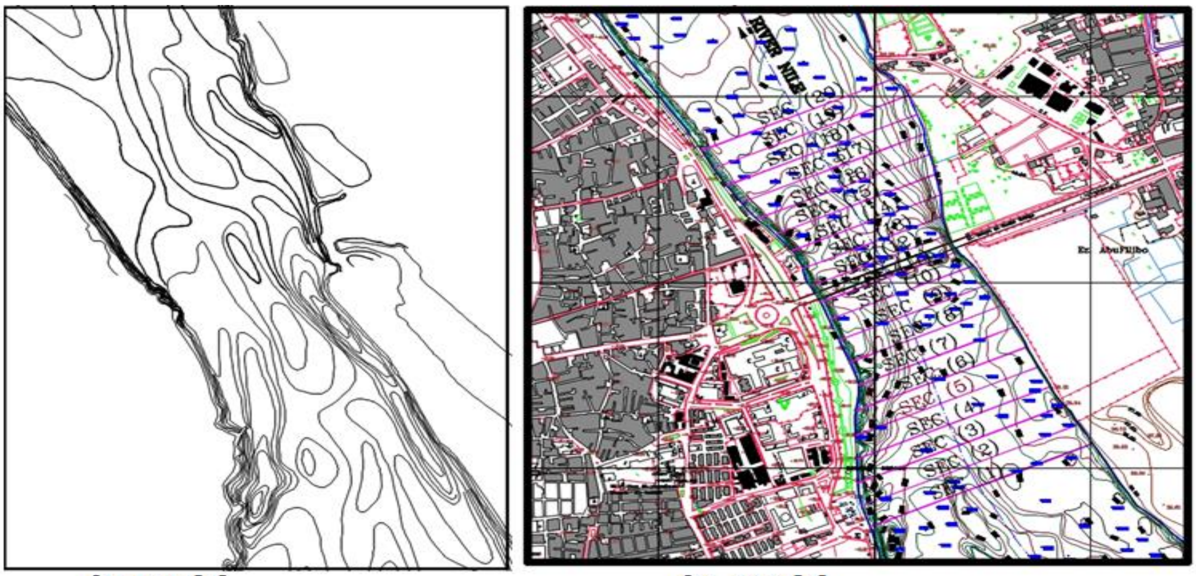


Fig 1. The fourth reach of the Nile River and the locations of Bani-Suef Bridge and El-Menia Bridge

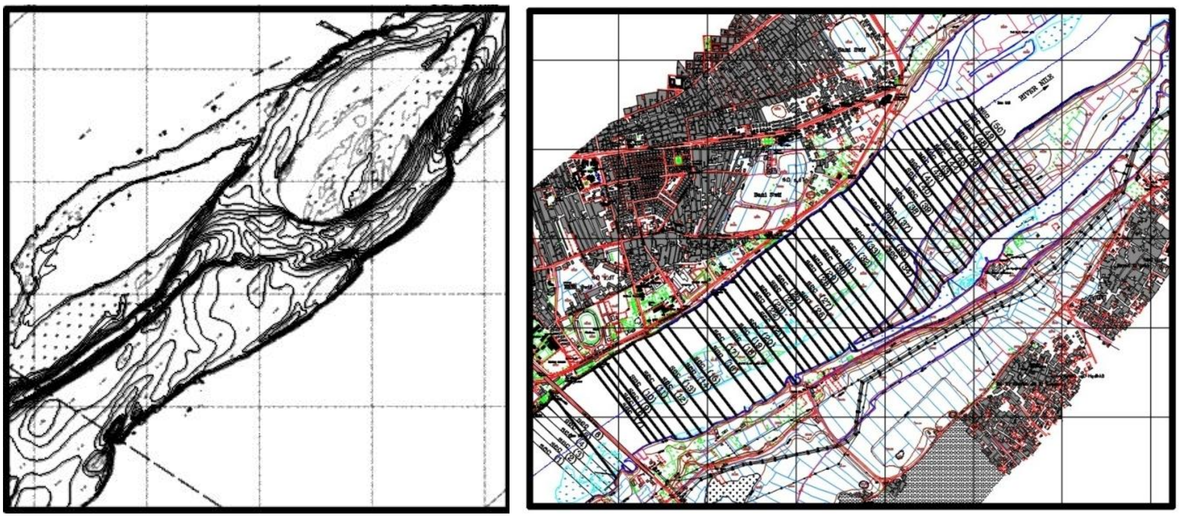
3. MATERIALS AND METHODS

Data was assembled concerning the geometric properties of the reach (i.e., cross-sections and profiles), the hydrologic data (i.e. discharge and water level), and maps. Geometric data is of significant importance to the present study. A hydrographic survey of the study reach was carried out by the Nile Research Institute (“NRI”) of the National Water Research Center in 1982, 2002, and 2004. The survey was carried out along the study area, between the two banks of the river, by surveying cross-sections spaced at 60 m intervals on average. The contour maps with a scale of 1:5000 were produced in 1982 and 2004, as shownin Figures 2 and 3. .Cross-sections, representing the entire study reach, were obtained from the contour maps using computer software. The number of cross-sections that were deduced for the study area were 20 (area 1) and 50 (area 2). Water depths obtained from the bathymetric survey were converted to bed elevations. The coordinates of surveying cross-sections were adjusted according to the guidance of the landmarks used during the survey for the years 1982, 2002, and 2004. Bed elevations were combined with riverbank elevations extracted from the land survey.



for 1982[8] for 2004[7]

Fig2. Nile bed contour map and surveyed cross-sections for the first area, NRI



for 1982[8] for 2004[7]

Fig 3. Nile bed contour map and surveyed cross-sections for the second area, NRI

4. DISCUSSION OF RESULTS

Due to the long dry seasons in some sections of the basin, its geological nature, and pouring rain caused by vast amounts of silt in the drainage systems, the Nile River's watersheds suffer greatly from soil erosion and land degradation. Stream channels that scour and fill regularly are thought to be degrading over time as the channel bed gradually aggrades. This occurred as a result of a shift in the sediment budget. The cross-sections were taken in 1982, 2002, and 2004, and were chosen to show the variations in channel geometry that occurred during these periods.

The deposition and scour values from 1982 to 2002 were determined for each cross-section of the two areas. They were also computed between 2002 and 2004. The average water level at each cross-section was used in the calculation. To assess the variation in depths, these cross-sections were compared (morphological changes).

The differences in bathymetric surfaces were displayed along some cross-sections to boost precision, as shown in Figures 4 to 6 for the first area studied between 1982 and 2002. Figures 7–9 show some cross-sections for the first area to compare 2002 and 2004. Figures 10 to 12 and figures 13 to 15 for the years 1982 to 2002 and 2002 to 2004, respectively, provide a sample of cross-section variations for the area between kilometers 807.8 and 810.87. They demonstrated erosion and sedimentation in these cross-sections.

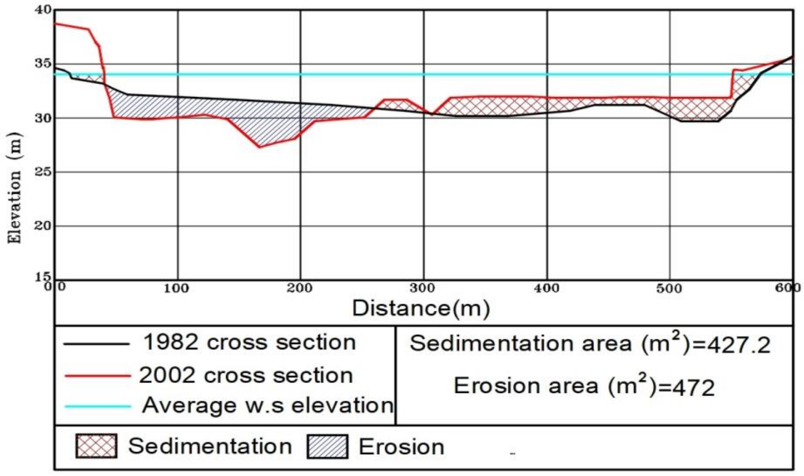


Fig 4. The deposition and scour at a cross-section at km 684.450 from AD.

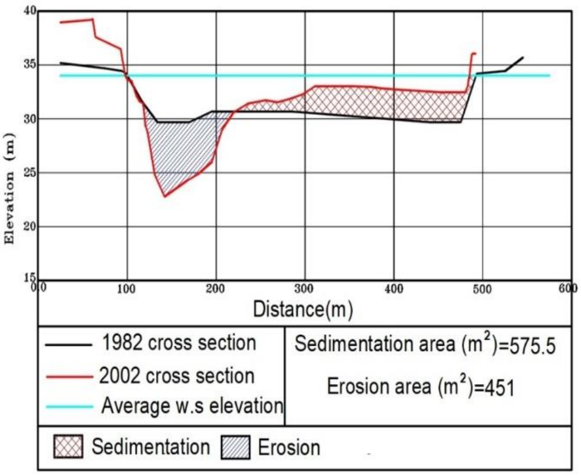


Fig 5. The deposition and scour at a cross-section at km 684.690 from AD.

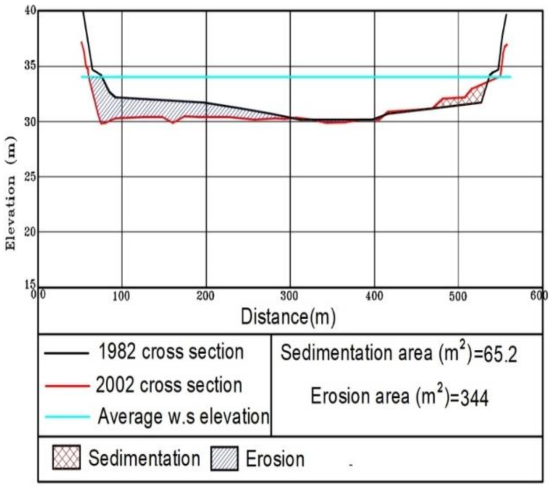
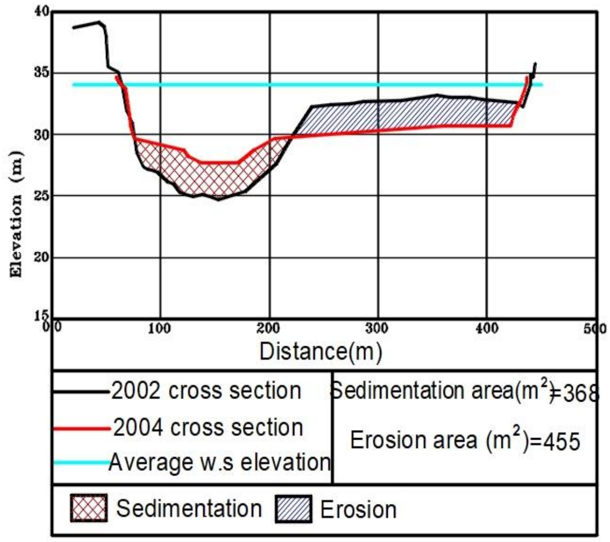


Fig 6. The deposition and scour at a cross-section at km 685.305 from AD.



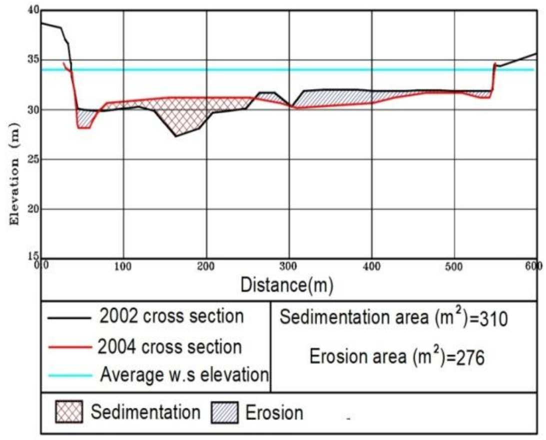


Fig 7. The deposition and scour at a cross-section at km 684.450 from AD.

Fig 8. The deposition and scour at a cross-section at km 684.820 from AD.

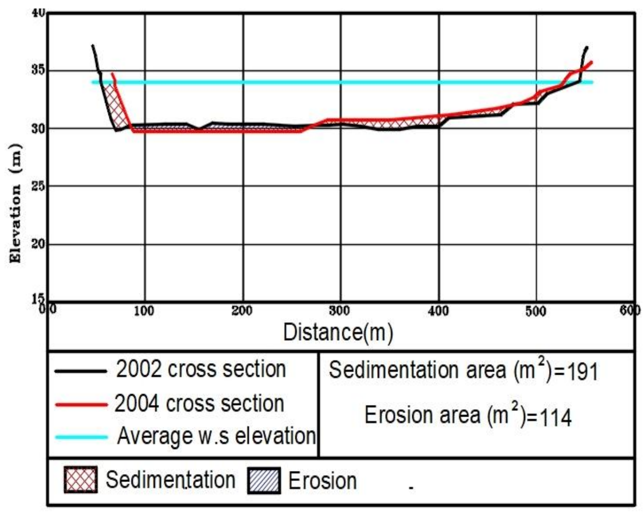


Fig 9. The deposition and scour at a cross-section at km 685.305 from AD.

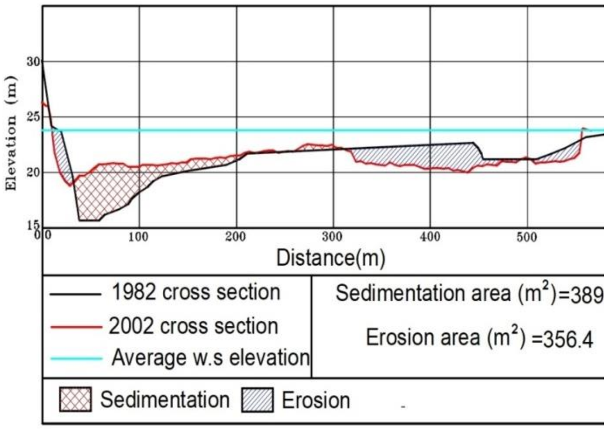


Fig 11. The deposition and scour at a cross-section at km 808.870 from AD.

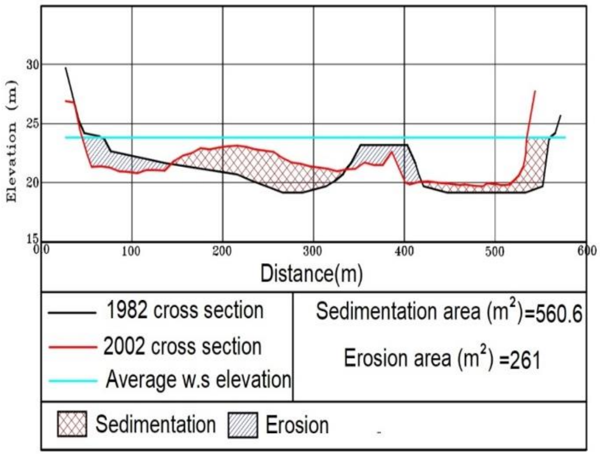


Fig 12. The deposition and scour at a cross-section at km 810.280 from AD.

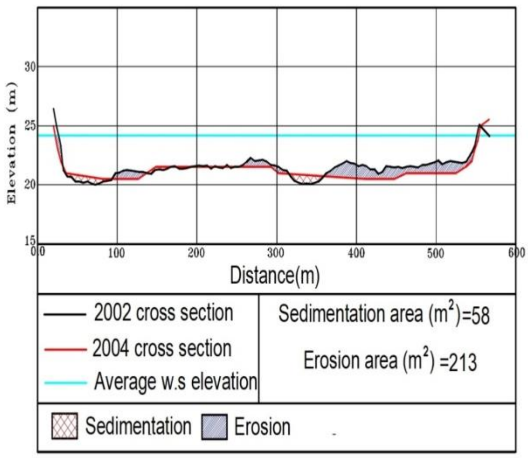


Fig 10. The deposition and scour at a cross-section at km 808.350 from AD.

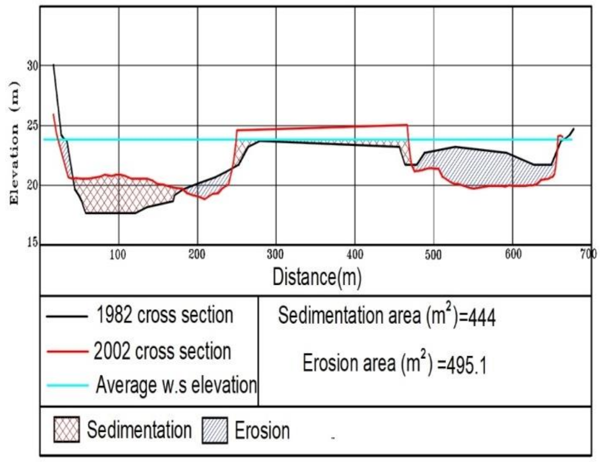


Fig 13. The deposition and scour at a cross-section at km 808.27 from AD.

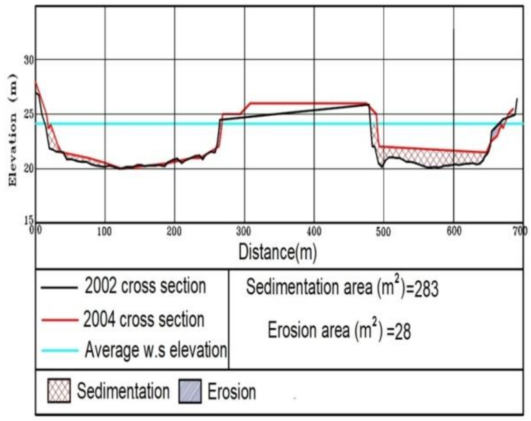


Fig 14. The deposition and scour at a cross-section at km 809 from AD.

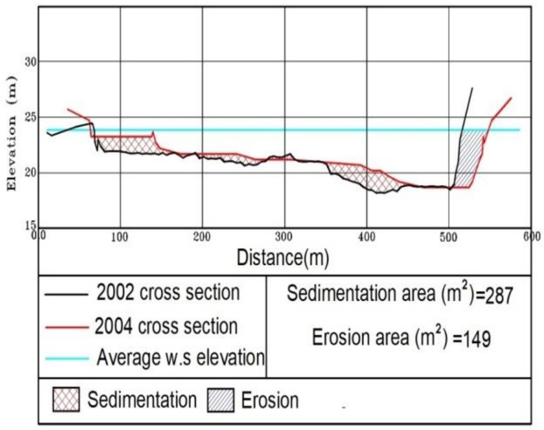


Fig 15. The deposition and scour at a cross-section at km 810.705 from AD.

Finally, the information was examined and graphed. Observations were documented and discussed using these graphics. A comparison was also conducted with the data to get a thorough picture of the environmental factors affecting the research area.
From the cross-sections shown, during the period 1982 to 2002, the net calculated volume of erosion in the first area, which extends from kilometre 684.33 to km 685.415, including El-Menia Bridge, was found to be 271950 m3. Between 2002 and 2004, the net volume of erosion materials reduced by 16700 m3. It is reasonable to suppose that erosion occurs more frequently than deposition on the bed. Even though it was an erosion zone, it was evident that the bed level was falling on the west side and rising on the east. It was also discovered that erosion happened on one side (the west side) while depositing occurred on the opposite side (the east side), which is where the navigation vent is located. Consequently, the navigation path was shifted to the west.
The second zone, which includes the Bani-Suef Bridge, runs from km 807.800 to km 810.870. Between 1982 and 2002, the net computed volume of deposits in this area was found to be 118073 m3. The net volume of sediment increased by 34068 m3 between 2002 and 2004. The second location was discovered to be the deposit area. It was implied that the poor water depth could present navigational issues. That was because of human interference (constructing, dredging). The complexity of navigation was caused by morphological changes (degradation and aggradation).

Due to an increase in flow velocity, scour occurred more frequently than sedimentation at the El-Menia Bridge area. On the west side of the bridge, the water velocity was higher than on the east side. On the east side, where the navigation vent is located, the deposition was concentrated.
Sedimentation happened more frequently than erosion in the Bani-Suef Bridge area. Due to the weakening of the water current, sedimentation resulted. The deposition also created a navigation bottleneck. When morphological changes were compared to what had previously occurred throughout the decades, it was discovered that they followed the same pattern. Table 1 shows the comparison between the two regions.

Table 1. Shows the comparison between the two regions

	El-Menia Bridge	Bani-Suef Bridge
Construction date	1987	1984
The reach	Reach four	Reach four
Site	Km 684.95 from AD.	Km 808.1 from AD.
Navigation path	At the east of the Nile River	At the west of the Nile River
Study area	From km 684.330 to km 685.415, from AD.	From km 807.800 to km 810.870, from AD.
degradation and aggradation.	Erosion area	Sedimentation area
Erosion and sedimentation rates	Erosion: 271950 m3	Sediment: 118073 m3

5. CONCLUSIONS

The goal of this study was to assess morphological changes in terms of channel design and breadth, as well as to quantify erosion and deposition along embankments in the studied region. The morphology of the Nile River is undergoing continuous changes over time. The consequences of these morphological changes are negative. When hydraulic constructions (such as bridges) are built across alluvial channels (such as the Nile River), they can cause morphological changes and navigation bottlenecks. According to the findings of the study:

a. To limit silt accumulation at the bed, a dredging operation is required.
b. Every 5 years, various cross-sections in the research area should be resurveyed to observe morphological changes.
c. More research is needed to address all problem areas, including the Nile River Bridges.
d. It is strongly advised that record-keeping procedures be developed and improved in a consistently uniform manner.
e. All construction actions should be prepared during the pre-construction dredging phase. Information about the initiative will be distributed to the locals. Studies to assess the nature and scope of the project's projected impacts should be carried out. In addition, the land acquisition should be looked at.

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