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Morphological Changes of the Nile River Reaches in Egypt after the Construction of the High Aswan Dam: The State of Art Review

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ملخص البحث

يعتبر نهر النيل هو شريان الحياه لمصر ويتكون من 4 احباس .وهناك العديد من العوامل التي تؤثر في الهندسه الهيدروليكيه لنهر النيل ويعتبر السد العالي واحد من اهم هذه العوامل.حيث يمثل نقطه تحول في خصائص النهر. من ضمن تأثيرات السد العالي حجز كميات الطمي التي كانت تغذي الاراضي الزراعيه لتجعلها من اخصب الاراضي .

ابحاث عديده تم اجرائها لدراسه تأثير السد علي تغيرات القاع في الاحباس المختلفه.واجمعت معظمها علي ان السد قام بحجز هذه الرسوبيات امام السد.اذن فهناك تعارض بين حجز كميات الترسيبات امام السد ووجود شكوي من اماكن كميات الترسيبات بها عاليه.سلوك الاحباس المختلفه هل هو ترسيب ام نحر ام وصل لحاله الاتزان.العديد من التساؤلات التي تحتاج لدراسه بخصوص المتغيرات المختلفه في نهر النيل بعد انشاء السد العالي.

فيما يلي سرد لبعض الاراء التي ناقشت الترسيب والنحر في الاحباس المختلفه.والتي ناقشت كميات الحمل الرسوبي للمواد العالقه وحركه القاع وتكون اماكن الترسيب والنحر ومدي تأثر كميات المواد العالقة الماره بانشاء السد العالي .ومدي تأثير تدخل العوامل البشريه المختلفه.

1 Abstract

The potential impact of human interference on the morphology and flow regime of the Nile River in Egypt (NRE) became one of the main topics to be studied to discuss the mechanism of morphological changes in Nile River after the construction of the High Aswan Dam. Many studies discuss the effect of High Aswan Dam (HAD) from the point of view the effect of reduce the suspended matter during the season of flood and how much suspended sediment material before and after the construction of HAD. The continuous change in bathymetry of the Nile River became an important point to study, Shear stress in the bed morphology, erosion and deposition, bed-shear stress distributions, transport rates along the river, and other many factors must be studied to understand the behavior of the Nile River. This behavior is erosion totally or deposition or reach to equilibrium state. Many questions need to discuss and find answers about all these variables in the Nile River after HAD.

Key words: Reaches of Nile River, suspended load, bed load, erosion and deposition.

2 Introduction

There is no doubt that High Aswan Dam (HAD) has the greatest hydraulic effect on the Nile River. The constructions of the HAD started in 1960 and was completed in 1968. By 1970 all major power facilities were in place and functional. The construction of HAD had made an obvious change in the morphology of the Nile River.

Many studies in different locations in the reaches of the Nile have been carried out to study the behavior of the Nile after the High Aswan Dam. All these studies said that the High dam stored the suspended materials comes with water in the upstream of the dam. There are many problems appeared in the Nile Reaches especially in the first and second reaches in the winter season (tourism season). The tourist's ships stopped due to low depth of water in certain locations. The Transport Nile Authority needs to dredge these locations to avoid these problems. Then, there is a conflict between the facts of there is no suspended materials passes through the dam and the depositions areas that in needed in continuous dredging works. The source of these deposition is must be studied in detail because its great effect on the morphological changes along (NRE).

3 Applications Studies

3.1 The effect of HAD on the morphology of the Nile river

D.J. Stanly (1996) [11] recorded the hydraulic structures had constructed to control flow along the Nile River. These structures are respectively Esna barrage (167 Km downstream HAD), the next structure is Naga-Hammadi Regulators (359 km), then Assuit Barrage at (544 Km), and finally the two-delta barrage at (946 Km) at Edfina on the Nile's Rosetta branch and Faraskour on the Damietta branch as mentioned at Fig. (1).

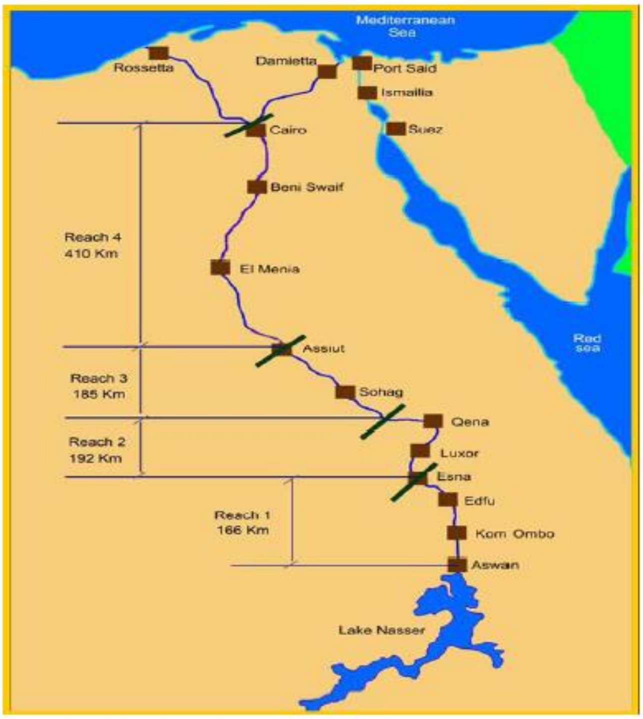

Figure 18 General layout for hydraulic Structures along the Nile River.

Ahmed and Fahmy (2014b) [4] suggests that the downstream part of the first reach was potentially not subjected to any degradation since HAD construction till year 2010. Actually, Ahmed and Fahmy (2014b) also found that HAD resulted in shoaling and accretion (deposition) to other areas such as Kom – Ompo and El-Gaafra at years 1991 and 2002 respectively.

Sharaf El Din (1977) [10] concluded that the dramatic reduction in fluvial discharge from the Nile River into the Mediterranean had caused an imbalance in the near-coast sediment budget, increasing erosion at the two mouths of the river and shifting the sediments along the coast.

Biswas and Tortajada (2012) [5] investigated that the dam has changed many of the natural characteristics of the Nile River. Among the major physical changes was the transformation of the river upstream of the dam from having a natural riverine hydrograph, into a strictly controlled and regulated channel downstream of the structure.

3.2 The effect of HAD on the sediment load

Concerning the suspended sediment concentration and suspended materials passes through the HAD, Extremely studies tried to get accurate numbers of sediment load.
Shalash (1980) [9] investigated that the suspended sediment concentration peaks at EL-Gaafra Station Gauging downstream the HAD have dropped from about 3000ppm before the construction of the dam to only about 50 ppm after the construction of the dam. The total sediment load had decreased by 97% after the construction of HAD as shown in, Table 8, which indicate the sediment concentration each month before and after the construction of the HAD. Besides, he concluded that the materials of the bed in the Nile river changed after the HAD to be consisted of 35% silt and 65% very fine sand, with average diameter =0.03 mm, and the clay disappeared from the sediment load.

Table 8 Sediment Concentration (ppm) in Nile flow downstream of the Aswan dam before and after the HAD.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
(1929-1955)	58	54	43	44	59	97	328	2800	2500	860	134	73
(1968-1977)	44	39	40	41	47	42	43	41	39	38	45	42

Sharaf El Din (1977) [10] Said that the amount of sediment transported to the Mediterranean Sea annually by the Nile was about (60-180 million tons) before the construction of HAD. The dramatic reduction in fluvial discharge from the Nile River into the Mediterranean has caused an imbalance in the near-coast sediment budget, increasing erosion at the two mouths of the river and shifting the sediments along the coast.

Abu-zied and El-shibini (1997) [3] were monitoring the suspended sediment passing Aswan in the Nile. they concluded that the amount of this suspended sediment was about 134 million tons/year on average before the construction of the HAD. The total dissolved solids (TDS) before the construction of HAD was in range (from 120 mg/l in September to 230 mg/l in June) but after the construction of HAD this range becomes average value 185 mg/l.

According to, (Eldardir, 1994) [6], at some years, the sediment load exceeded 100 million tons through the Nile River.

Sattar and Raslan, (2014), [8] investigated a numerical calibrated 2D model to predict the change in morphology downstream Naga-Hamadi barrage at extreme high flood discharge at Nile River. The suspended sediment load reduced from 129 million tons/year to less than 26.3 million tones/year after HAD in 1964.The estimated value transmitted by the Nile River is in the range of 10-100 Kg/s.

Abdelbary et al., (1996) [1] found that the suspended sediment load reduced from 129 million tons/year to 26.3 million tones/year after HAD in 1964, 4.2 million tons/year during 1965-1967, and stabilized at 2.27 million tons/year in the period of after 1967.

By measuring the sediment load and bed load by Nile Delft sampler, Abdel-Fattah et al., (2004) [2] investigated that the exact amount of sand transported across the Nile River to the sea is still unknown but this amount is about 10-100 kg/s. The maximum velocities also reduced as an effect of the HAD to become 1.0-1.50 m/s instead of 1.50-2.00 m/s before HAD. The maximum sediment concentration had become 0.03- 0.1 Kg/m^3 instead of 4 Kg/m^3 at high flow before HAD. By site measurements in the 4^{th} reaches of the Nile River, it is observed that the measured suspended load transport rates are larger than the bed load transport rates in the Nile River as shown in Table 9.Where, the Total load = Suspended load + Bed load.

Table 9 Comparison between the measured suspended-load transport rates and the Bed load transport rates. Abdel-Fattah et al., (2004) [2]

Cross section	Measured Suspended-load transport rates integrated over the cross section(kg/s)	Total Measured load transport rates integrated over the cross section(kg/s)	Bed-load transport rates integrated over the cross section(kg/s)
Aswan	4.4	6.1	1.7
Quena	8.9	12.1	3.2
Sohag	47.9	55.1	7.2
Bani-Sweif	15.8	19.7	3.9

3.3 Studying Erosion and deposition in the Nile River

Enrica Viparelli et al., (2013) [12] said that at the dynamic equilibrium stage, the deposition sediment through the floodplain is balanced by the erosion which was eroded by the floodplain. The fraction of the bed materials plays an important role in the morphological change in the river system. The equilibrium in governed reach depend on the upstream supply and the floodplain morphological change.

Dredging is considered another face of human interference which took place in several locations along the Nile River to achieve an acceptable water depth for navigation. In the second reach, dredging caused a water level drop that was evident during high medium and high flows in the period between 1995 and 2009 Enrica Viparelli et al., (2013) [12]**.**However, this drop in water level was not pronounced during low flows. Changes in water level can cause a change in depth averaged velocities and bed shear stresses, which can lead to a subsequent change in the morphology and river regime in general.

Ismail and Samuel, (2011) [7] Concluded that the amount of dredge is approximately 500,000 m^3 from 1995 till 2009. They tried to collect data to understand the behavior of the morphology of the different reaches by using HEC-RAS computer model. They can obtained the rating curve for the four reaches, as shown in Figure 19, which show the rating curve downstream old Aswan dam as an example. In addition to discharges passes through Esna barrage at the period of 1995-2009, as shown in Figure 20.

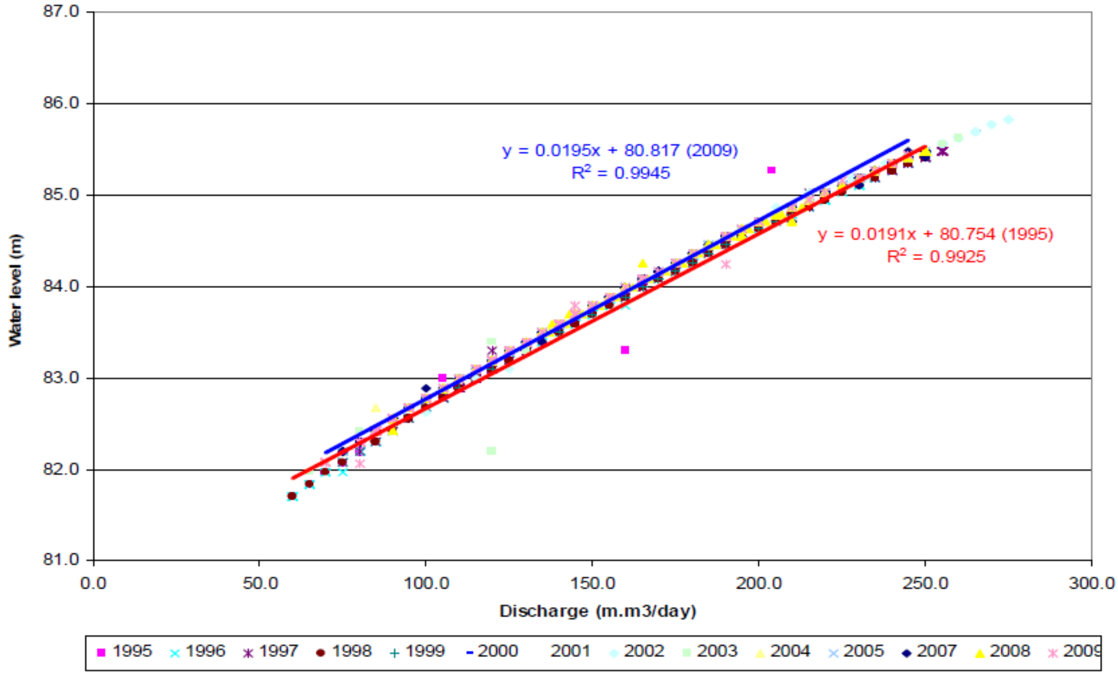

Figure 19 Downstream Old Aswan Dam rating curve.

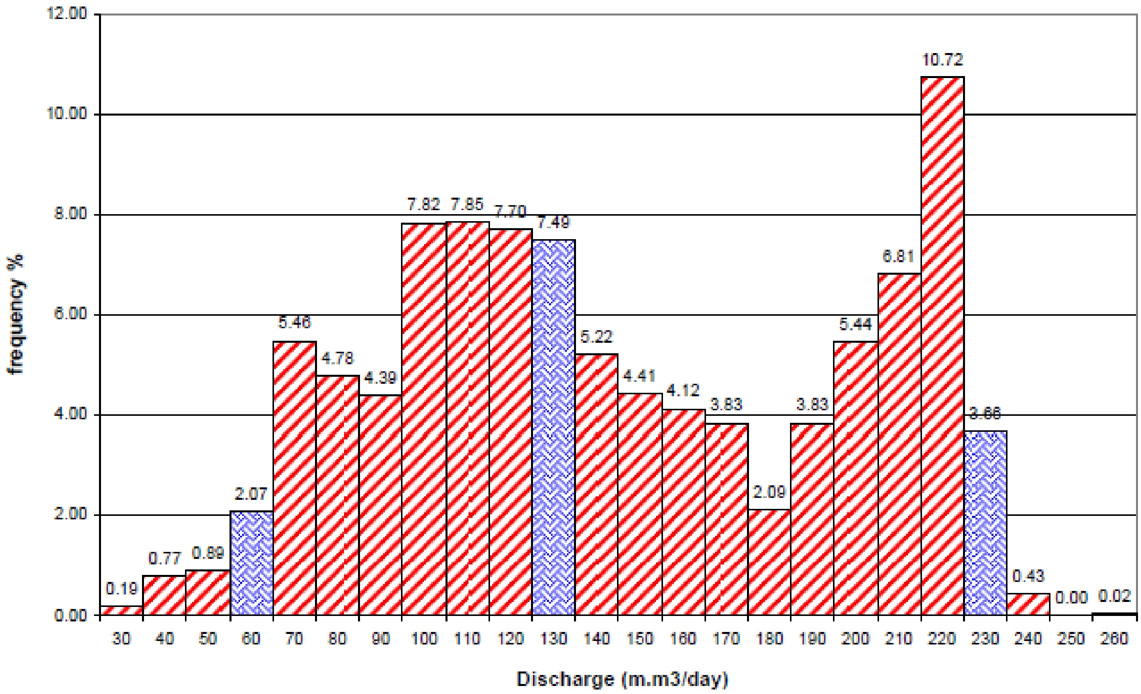

Figure 20 Frequency percentage of discharge through the period 1995-2009 for the second reach.

For the second reach, the minimum discharge was 60 million cubic meters per day during the period 1995-2009.However, the maximum discharge was 230 million cubic meters per day during the same period.
Changes in water level can cause a change in depth averaged velocities and bed shear stresses, which can lead to a subsequent change in the morphology and river regime in general. The amount of dredge is approximately 500,000 m^3 from 1995 till 2009. The study concluded that for the third reach there is no significant water level drop due to dredging. (Ismail and Samuel, (2011) [7].

Biswas and Tortajada, (2012) [5] show that the major physical changes were the transformation of the river upstream of the dam from having a natural riverine hydrograph, into a strictly controlled and regulated channel downstream of the structure. The annual suspended load decrease till arriving to the delta then to the Mediterranean Sea before the construction of HAD, but this suspended load increase after the construction, as shown in Figure 21. The reason of this increase in the suspended load not only because of the effect of the construction of the HAD but also there are other many natural factors like the sediment come from valley or channels in the rainy season, wind-blown sand and inflows com to the river from the drainage system. There is no data about sediment balance after the construction of HAD.

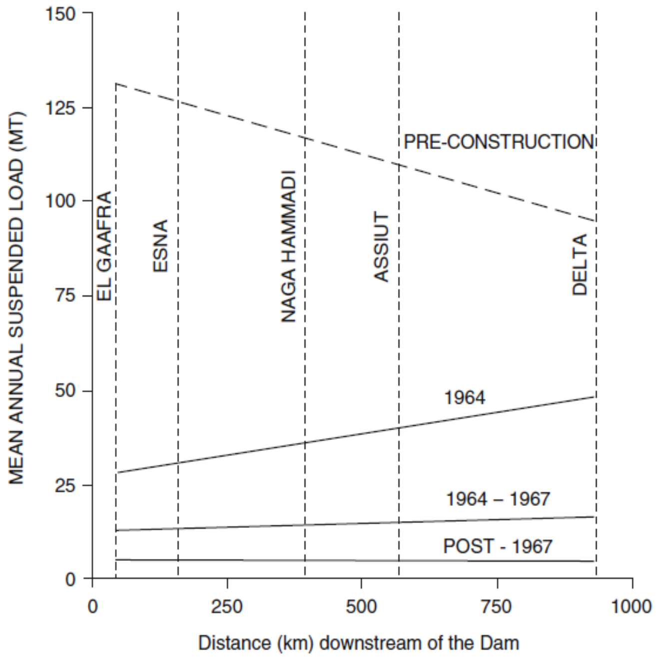

Figure 21 Suspended sediment loads in the Nile downstream of Aswan

Sattar and Raslan, (2014) [8] investigated numerically by using calibrated numerical 1D model the predicted erosion along 4 Km downstream Naga Hamadi barrage with variability in discharges as shown in Figure 22.They concluded that the erosion increased as the discharge increased.

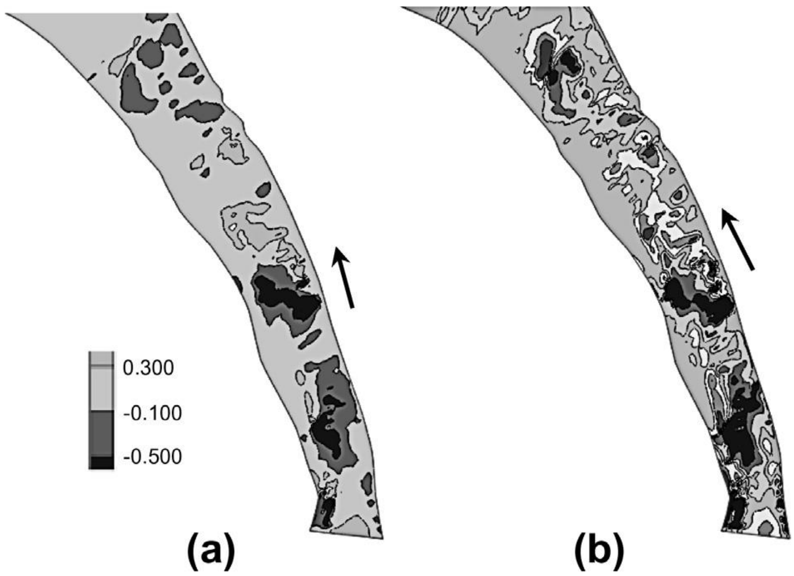

Figure 22. Perdicted Erosion pattern along 4 km in the near field downstream Naga-Hammadi Barrage; (a) Q= 3700 m^3/s and (b) Q= 4700 m^3/s.

4 Conclusion and Recommendation

Background knowledge in the Nile river Given the potential future variability in fluvial discharge, upstream of HAD, as well as the variety of the amounts of suspended sediment in the literature review, the river regime downstream has not been fully explored. Therefore, Hydrographic survey must be measured and the regime change must be focused to investigate the behavior of the river regime on a reach scale.

A multidimensional 2D numerical model must be constructed for the different reaches of the Nile River based on collected data and measurements and the historical data to show bed-shear stress distributions and transport rates along bends, crossings and areas in straight channels. Relationships between transport and bed-shear stress can be deduced and also relationships between shear stress and amount of sediment storage in the bed.

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