Nature of the Distributed of the Bed Sediment within Mosul Dam Reservoir, Iraq

Nadhir Al-Ansari **Issa E. Issa** **Sven Knutsson**
nadhir.alansari@ltu.se issa.elias@ltu.se sven.knutsson@ltu.se
Lulea University of Technology, Sweden

Abstract

Mosul Dam is one of the biggest hydraulic structures in Iraq. It was constructed in 1986 on the Tigris River in the north of Iraq. The initial storage capacity and water surface area of its reservoir reaches 11.11 km^3 and 380 km^2 respectively at the maximum operation level 330 m a.s.l. The dam was operated in 1986. A total of 56 samples were collected from the bottom of Mosul reservoir covering most of the reservoir area. The results of the analysis of these samples revealed that they were composed of gravel (3.8%), sand (15%), silt (55.5%) and clay (25.7%). The distribution of these sediments indicates that the silt portion represents the highest followed by clay and then sand. However, sand percentages are the highest in the northern zone of the reservoir where the River Tigris enters the reservoir and decreases gradually toward the dam site. In the meantime, silt percentage decreases toward the dam site while the finer fraction (i.e. clay) increases.

Keywords.Mosul dam, reservoir sedimentation, sediment size distribution, sediment characteristics.

طبيعة توزيع رسابات القعر في خزان سد الموصل - العراق

عيسى الياس عيسى **نضير الانصاري** **سفن كنتسون**
جامعة لوليا / السويد جامعة لوليا / السويد جامعة لوليا / السويد

الملخص

سد الموصل واحد من اكبر المنشآت الهيدروليكية في العراق كان قد انشىء عام 1986 على نهر دجلة شمال العراق. سعة الخزين الاولية والمساحة السطحية لبحيرته يصل 11.11 كم^3 و 380 كم^2 على التوالي عند اكبر مستوى للتشغيل 330 م فوق مستوى سطح البحر. ست وخمسون عينة من رسوبيات قعر الخزان كانت قد جمعت لتغطي معظم مساحة البحيرة. نتائج التحليل الميكانيكي لهذه الرسوبيات اظهرت ان نسبة الحصى كانت3.8% والرمل 15% والغرين 55.5% والطين 25.7%. نتائج توزيع الرسوبيات بينت ان نسبة الغرين هي اعلى من الطين والرمل بينما ان نسبة الرمل كانت اعلى في الجزء الشمالي للخزان في المنطقة التي يدخل فيها نهر دجلة الى البحيرة وتقل تدريجيا باتجاه الخزان، في غضون ذلك نسبة الغرين تقل باتجاه موقع السد بينما نسبة المواد الناعمة (مثل الطين) تزداد.

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Introduction

Dams are usually constructed for water resources management purposes. They might be of multipurpose functions like flood prevention, irrigation and/or power generation, etc. In all cases once the dam is constructed the sediment transport capacity of the streams is reduced upon enteringthe reservoir due to the decrease of flow velocity and the increase flow cross sectional area.Most of the sedimentsare usually deposited in the reservoir headwater area except the fine grained particles that are expected to be farther transported and deposited within the vicinity of the dam. The sedimentation rate depends on the amount of sediment transported by the stream, sediment production in the catchment area and the mode of deposition [1].On the other hand, reservoir sedimentation depends on the geometry and operational procedure of the reservoir, river regime and its flood frequencies, sediment consolidation, flocculation, and density currents as well as possible changes in land use [1].

When dams are constructed on rivers, they dramatically alter the balance of sediment inflow and outflow. This change will affect the function of the reservoir.More than 90% of the sediments are usually trapped within the reservoir [2]. Most of the sediments will be trapped within the reservoir and only fine particles are released downstream [3 and 4].

In this research, a total number of 56 sediment samples were collected from the bed of Mosul reservoir to study their nature and distribution. This study intends to characterize the sediments deposited within the dam reservoir vicinity in terms of their sizeand their distribution within the reservoir.

The Mosul Reservoir

The Mosul reservoir is located between latitude (4055000 to 4086000) m Northing and longitude (275000 to 320000) m Easting (Figure 1). The length of the reservoir is about 45 km and its width ranges between 2 and 14 km at the maximum operation level of 330ma.s.l. The greatestwater surface area of the reservoir is calculated to be 380km^2 at the maximum operation level of330 ma.s.l.The storage capacity of the reservoir reaches 11.11 km^{3}of which 2.95 km^3 aredead storage [5]. The catchment area of the River Tigris estimated above the Mosul dam is about 54900 km^2 shared by Turkey, Syria and Iraq [6]. The main inflow entering the reservoir is from the River Tigris.There are 10 valleys contributing to Mosul reservoir (Table 1).

Figure 1. Iraq map showing the location of Mosul Dam.

Table 1.Some properties of the main tributary valleys surrounding the Mosul Reservoir from both eastern and western sides.

Valleyname	Sidefeeding	Area km^2	Slope	Length km	Mean basin level ma.s.l
Sweedy	Right	450.76	0.0359	38.8	446.62
Kara Kandy	Right	78.52	0.0217	21.82	388.38
KhuyrHara	Right	50.06	0.0525	10.86	404.89
Amlik	Left	88.95	0.0281	38.94	470.42
Jardyam	Left	88.73	0.0215	52.68	457.1
Affkery	Left	139.5	0.0214	58.04	445.34
KhrabMalk	Left	119.6	0.0255	51.32	475.87
Naqeb	Left	104.1	0.0143	54.71	426.52
Kalaq	Left	162.26	0.0173	60.52	424
SaeedThaher	Left	92.25	0.026	43.23	414

Mosul dam operates to provide storage for three irrigation projects, power generation, regulation and flood control for the Tigris River and also for recreation. Dam operation started during June, 1984 with the initial reservoir filling during the spring of 1985 but the actual operation began in July, 1986 [5].

Data Collection and Methodology

Fifty-six sediment samples were collected from the bottom of the Mosul reservoir using a Van Veen grab. The work was conducted in May 2011, twenty six years after the initial impounding, using a boat equipped with *"Real-Time Kinematic Global Positioning System (RTK-GPS)"* and an echo sounder Sea Charter 480DF to define the absolute x,y,z coordinates of the reservoir bottom during sampling. The locations of the samples, which were collected across the entire bottom of the reservoir, were projectedon the satellite image using Arc/GIS software (Figure 2). To determine the size distribution of the sediment, all the samples were sieved at Mosul University labs. The fine fraction (silt and clay) was subjected to hydrometer analyses at the same labs.

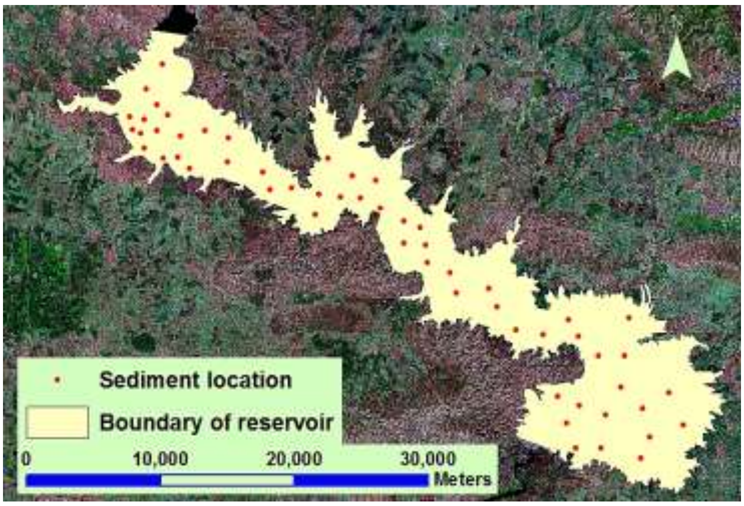

Figure 2.Location map of sediment samples.

Results Interpretation and Discussion

Over all the grain size analyses of the bed samples from the Mosul reservoir indicate that the sediments comprised Gravel: Sand: Silt: Clay in the ratios 3.8:15:55.5:25.7 respectively. The silt portion occupies 77% of the surface area of the bottom of the reservoir followed by clay 13.5% and sand with gravel 9.5% (Figure 3). The sand dominated areas are confined near the shores of the reservoir while the clay occupies the deepest parts of the basin.

From Folk's (1954) textural perspective using classification, [7 and 8]. The sediments are mainly dominated by silt reaching 42.86%, which are followed by mudstone 19.64%, and clay 10.7% on the gravel: sand: mud triangle, while on the sand: silt: clay triangle gravelly muddy sand is the dominant 16.1%, followed by slightly gravelly muddy sand 5.36% and 5.34% divided between gravelly mud, slightly gravelly sandy mud and sandy silt (Figure4). Al-Taiee [9] reported that sediment at the bottom of the reservoir were 70% silt loam, 11% silt, 11% silt clay loam and 8% loam. This is due to the fact that he used soil classification for agricultural purposes.

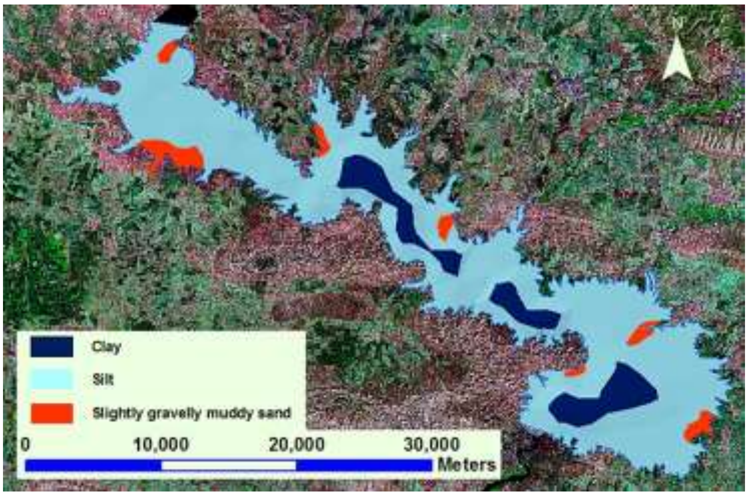

Figure 3. Map of the Mosul Reservoir showing the deposition pattern of various sediment size fractions.

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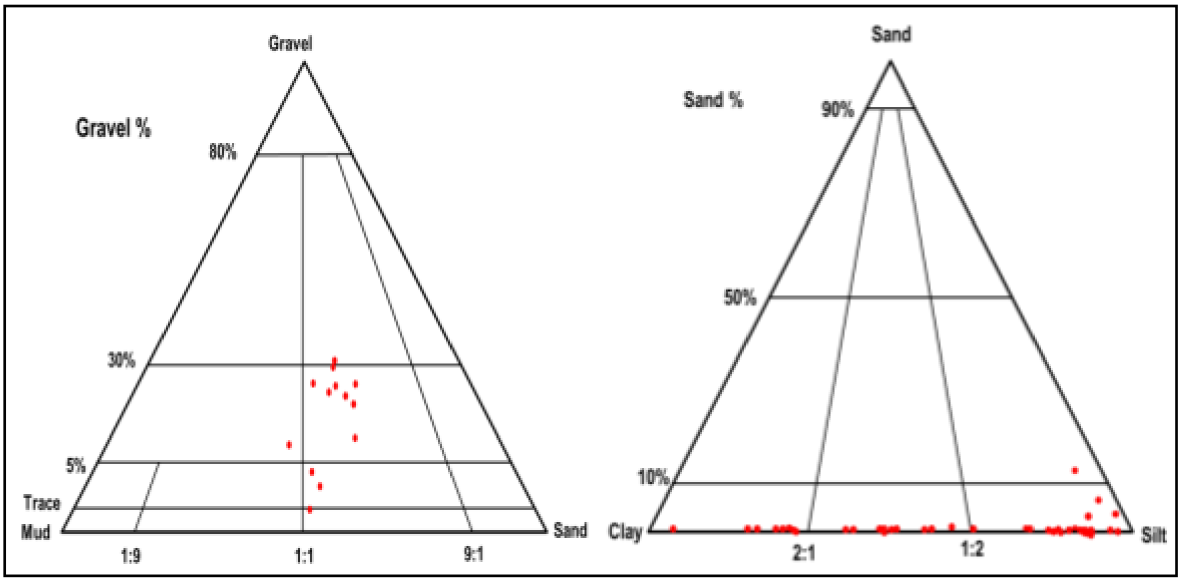

Figure 4.Plot of bed sediment samples of Mosul Reservoir using Folk (1954) Classification.

Gravels and sand are confined in patches near the entrance of tributary valleys on both eastern and western sides of the reservoir together with the entrance of River Tigris from north (Figure5). On the other hand, silt and clay cover most of the surface area of the reservoir bottom. The latter sediment sizes always occupy the relatively deep parts of the reservoir (Figure5).In addition, the longitudinal distribution of the sediments also confirms this pattern (Figure6). In Figure (6), it is quite evident that the sand percentages are higher in the northern zone of the reservoir where the River Tigris enters the reservoir and decreases gradually southward. Silt percentages decrease toward the dam site in the south while the clay fraction increases in the same direction. This is a very common pattern [10, 11, 12 and 13] when a reservoir has one main feeder like the Tigris River in our study case, because the velocity of water entering the reservoirs drops tremendously and suddenly causing the deposition of coarse refractions near the feeder entrance

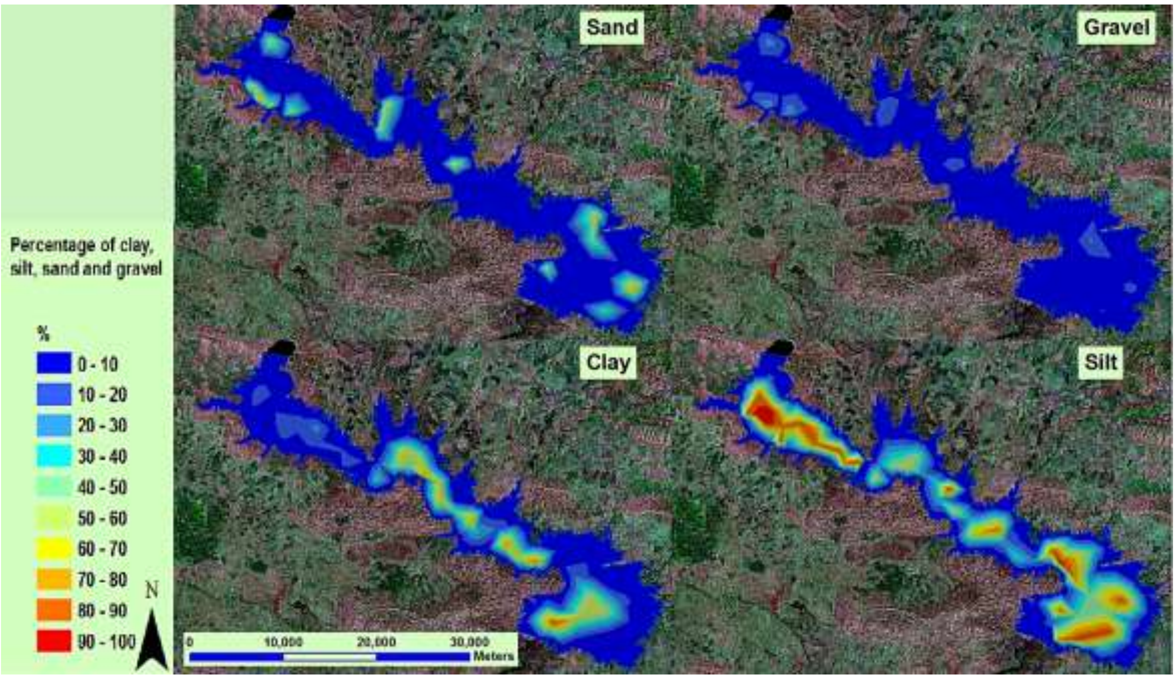

Figure 5.Distribution of the Gravel, Sand, Silt and Clay fractions of the bottom sediments throughout the Mosul Reservoir.

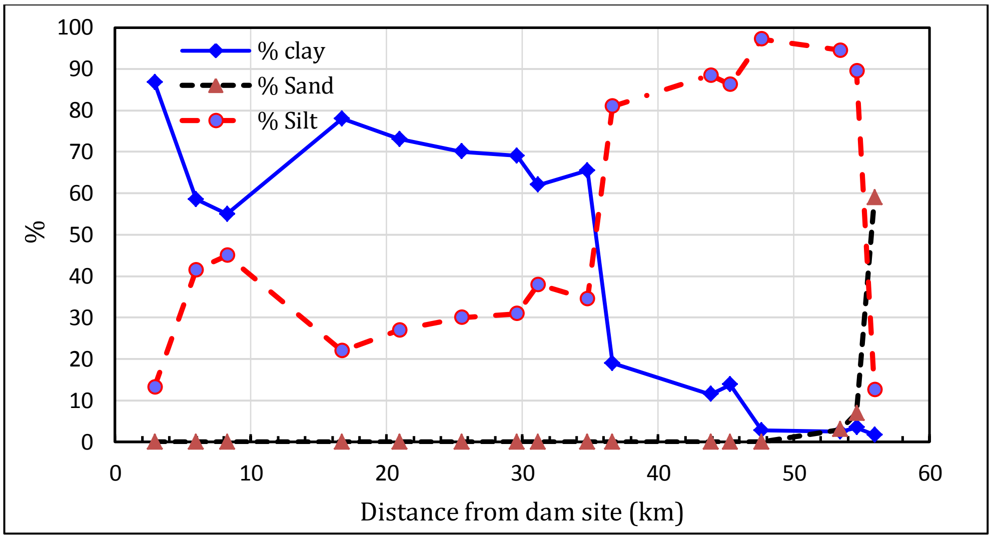

Figure 6.Longitudinal distribution of sand, silt and clay fractions in the bottom sediments across the Mosul Reservoir.

Summary and Conclusion

The Mosul reservoir storage capacity was reduced by 1.143 km^3 due to sedimentation during the period of 1986-2011 whereas the original capacity was 11.11km^3. This suggests an average annual sedimentation rate of 45.72×10^6 $m^3.yr^{-1}$. Most of the sediments were deposited within the northern zone of the reservoir where the River Tigris entrance is located. The rate of reduction in volume capacity decreases gradually from in the northern zone (7.74%), to the middle zone (3.87%) and then to the southern zone (3.12%) [14].

Bottom sediments of the Mosul Reservoir are composed of various size fractions ranging from Gravel (3.8%), to Sand (15%), to Silt (55.5%) and then to Clay (25.7%). The distribution of these sediments indicates that the silt portion represents the highest 77% of the bottom sediments of this reservoir followed by clay (13.5%) and then sand with gravel (9.5%). However, sand percentages are the highest in the northern zone of the reservoir where the River Tigris enters the reservoir and decreases gradually toward the dam site. In the meantime, silt percentage decreases toward the dam site while the finer fraction (i.e. Clay) increases. The samples were classified and they are: Silt (45%) followed by Mud (23%), Sand (21%) and Clay (11%).

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