JOURNAL OF
ENVIRONMENTAL HYDROLOGY

The Electronic Journal of the International Association for Environmental Hydrology
On the World Wide Web at http://www.hydroweb.com

VOLUME 13 2005

DISTRIBUTION OF BED SEDIMENT MATERIAL IN THE MOSUL RESERVOIR, IRAQ

Thair Mahmood Al-Taiee

Research Center for Environment and Water Resources
Mosul University, Iraq

The nature of the bed sediment material distribution in the Mosul dam reservoir is studied. A total of 37 bed sediment samples from the reservoir were collected. The laboratory analysis revealed that the dominant fraction of surface bed sediments is silt (64.8%) followed by sand (19.6%) and clay (15.6%). Furthermore, the dominant ranges of the sediment along the bed were 10% to 30 % for sand, 50% to 70% for silt, and 20% for clay. The percentage of clay in the bed sediments increased from the upstream reach of the reservoir downstream toward the dam. The D_{16}, D_{50} and D_{90} values decreased toward the dam with a small decrease toward the upstream of reservoir near the confluence of the old Tigris River and the reservoir. Finally, relatively homogeneous bed materials represent about 18% of the total reservoir bed area.

INTRODUCTION

Reservoir sedimentation is a complex, troublesome process having its major effects on the economies of product development. The loss of storage capacity due to silting processes that are a result of the deposition of stream sediments is the most important problem in the maintenance and development of storage reservoirs. Reservoir sedimentation considered here includes the study of sediment types that have accumulated in the reservoir, the distribution of sediments in the reservoir, the trap efficiency of reservoir, the aggradation above a reservoir, and a reservoir sediment survey.

The movement of sediment into a reservoir is governed by two dynamic forces acting on individual sediment particles, the horizontal component which is due to gravitational pull supplemented by the fluctuating forces in both upward and downward directions (Borland, 1957).

The particle size distribution is useful in predicting erosion transport, deposition and compaction of sediments. The size distribution of incoming sediment is very important in determining the pattern of deposition in a reservoir and is one of the most important aspects in the evaluation of the amount of space a given weight or quantity of transported sediment will occupy in reservoir.

The pattern of how these sediments are eventually distributed depends upon several interrelated factors; size, texture of sediment particle, reservoir inflow-outflow, size and shape of reservoir, and reservoir operation schedule (UNESCO, 1985). Finally the location of sediment deposits in the reservoir area and the old river channel above the dam are of prime importance to the engineers responsible for design and allocation of space needed for dead storage of sediment.

MECHANISM OF RESERVOIR SEDIMENT DISTRIBUTION

The behavior of sediments within reservoirs and lakes is determined by various forms of water circulation, which establish areas of scour and accretion (Vanoni, 1977; Sly, 1978). Generally, deposition begins with coarse sediment dropping in the reservoir headwater area gradually building a delta where the river enters the reservoir with some of the finer particles transported by density currents down to the dam. The delta consists of regular top set and fore set beds, with bottom set beds extending from the front of the delta along the old river channel all the way to the dam (Vetter, 1953). This is shown in Figure 1. The bottom set bed consists of very fine material of low specific gravity and high water content, with some near the dam at the top of deposits. The top set beds of the delta consist of much coarser material of greater unit weight and less water content.

It becomes necessary to run a reservoir sediment survey after some period following closure of the dam. The surveys are run primarily to update the capacity data necessary to operate the reservoir more efficiently. Other valuable information and data are furnished as a result of these surveys.

STUDY AREA

Mosul reservoir is one of the largest artificial water reservoirs in Iraq. It was impounded by the construction of the Mosul dam on the Tigris River about 60 km north of Mosul city. The maximum surface area of the reservoir is about 385 km^2 at the maximum operation level (330 m.a.s.l.) with a maximum storage volume of 11.11×10^9 m^3. The drainage area of the Mosul reservoir lies within Iraqi lands and has an area of about 4200 km^2. A mountainous region surrounds the reservoir.

The main source of water inflow to the reservoir is the Tigris river which flows from Turkey entering Iraq near the village of Faish-khabour. Mosul reservoir is efficient as a sediment material

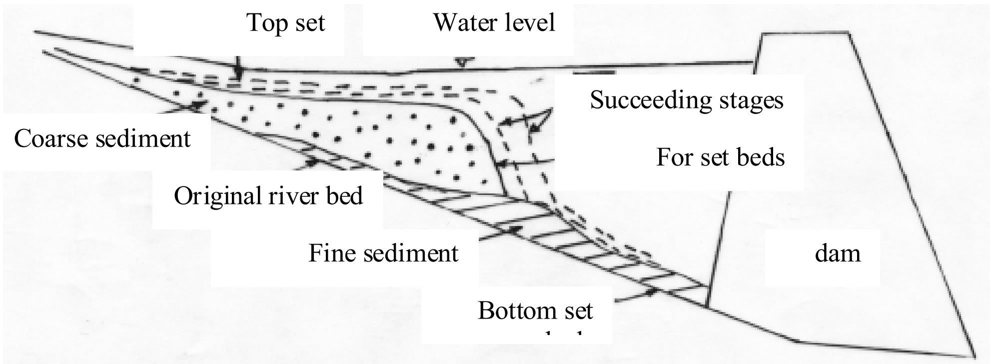

Figure 1. Profile of a typical reservoir bed sediment.

trap. The computed sediment transport rates post dam construction decreased, declining from a mean annual value of 1100 mg/l to 59 mg/l, (Al-Taiee, 1990). The calculated trap efficiency for the time between the starting operations of the reservoir (1985) until the end of the year 1992 is 95% (Al-Taiee, 1993).

FIELD WORK

In order to determine the nature of the sediment distribution on the bed of the Mosul reservoir, a total of 37 surface bed sediment samples were collected using a Van Veen bottom grab sampler fixed on a boat. The locations of these samples were selected logically and scientifically using 1:10000 topographic maps covering almost all the reservoir area (Figure 2). The collected sediment samples were tested and analyzed in the laboratory.

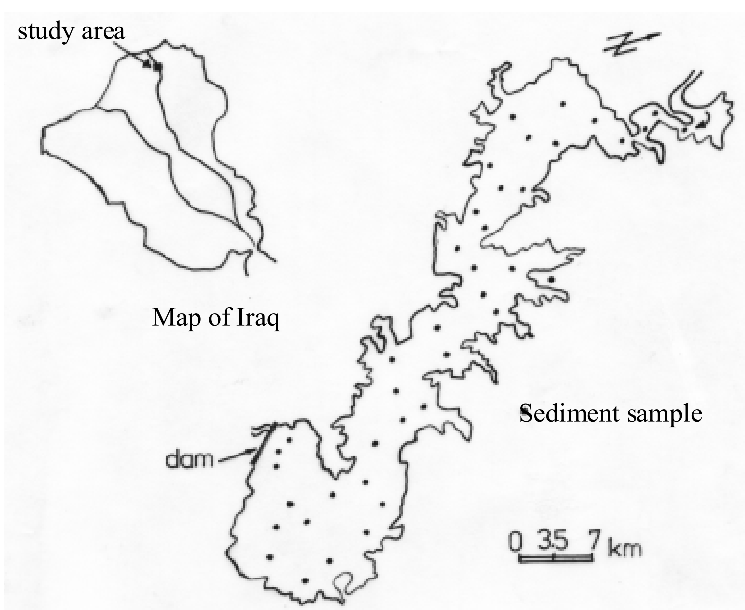

Figure 2. Location of the bed sediment samples in the studied reservoir

The fine portion of each sample (silt and clay) was tested using the hydrometer method to determine its grain size distribution. These small sizes (clay, silt and perhaps the fine sand) are of primary interest in the reservoir sedimentation studies.

RESULTS AND DISCUSSION

A laboratory analysis of the collected samples of the reservoir sediment from all the locations using the hydrometer test showed that the average silt: sand: clay ratio was of the order 19.6:64.8:15.6. All the sediment samples were classified according to Folk, 1954.

The texture classification indicates that 70% of the samples were silt loam, 11% silt, 11% silt clay loam and 8% loam. When these types were analyzed for their distribution on the bed of reservoir, it was found that each type covers 79%, 6%, 10% and 5% of the total area of reservoir respectively (Figure 3).

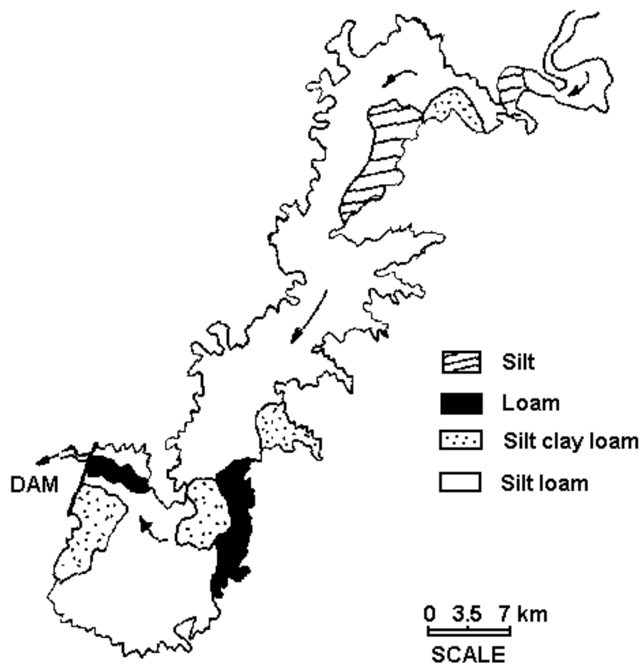

Figure 3. Mosul reservoir bed sediment classification.

Figure 4 shows the grain size distribution of some selected samples from the collected sediment samples. This figure indicates that the samples nearest to the dam have the finer particles. This is due to the settling processes that occur in the large particles in the upstream part of the reservoir as a result of the decrease in the water velocity of the currents.

The fine particles still in suspension are transported and deposited downstream in other locations of the reservoir (Figure 5). This figure shows that the percentage of clay in the bed sediment increases toward the dam due to the above-mentioned reason.

The distribution of the values of D_{16}, D_{50}, and D_{90} of the sediment samples along the reservoir were taken at locations shown in Figure 6. The D_{16} ranges between 0.001 mm near the dam to 0.0045 mm at a distance of 45 km upstream from the dam, with an average value of 0.0025 mm. The D_{50} ranges between 0.003 near the dam to 0.023 mm at a distance of 45 km upstream the dam with an average

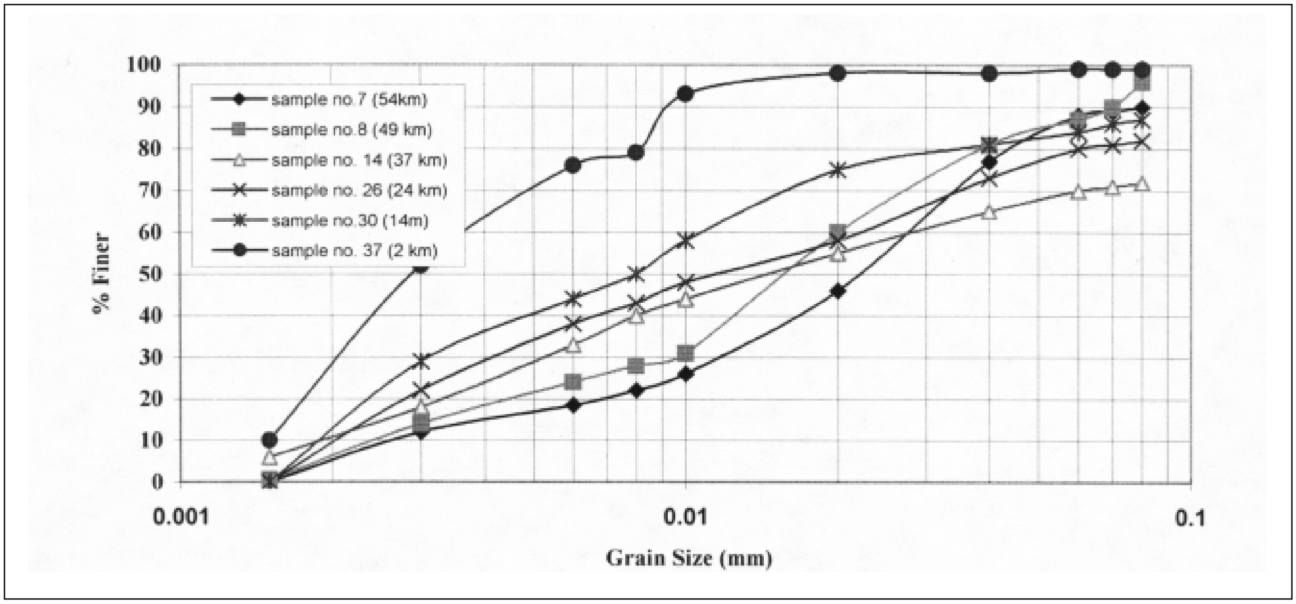

Figure 4. Grain size distribution analysis for the surface bed samples of Mosul reservoir.

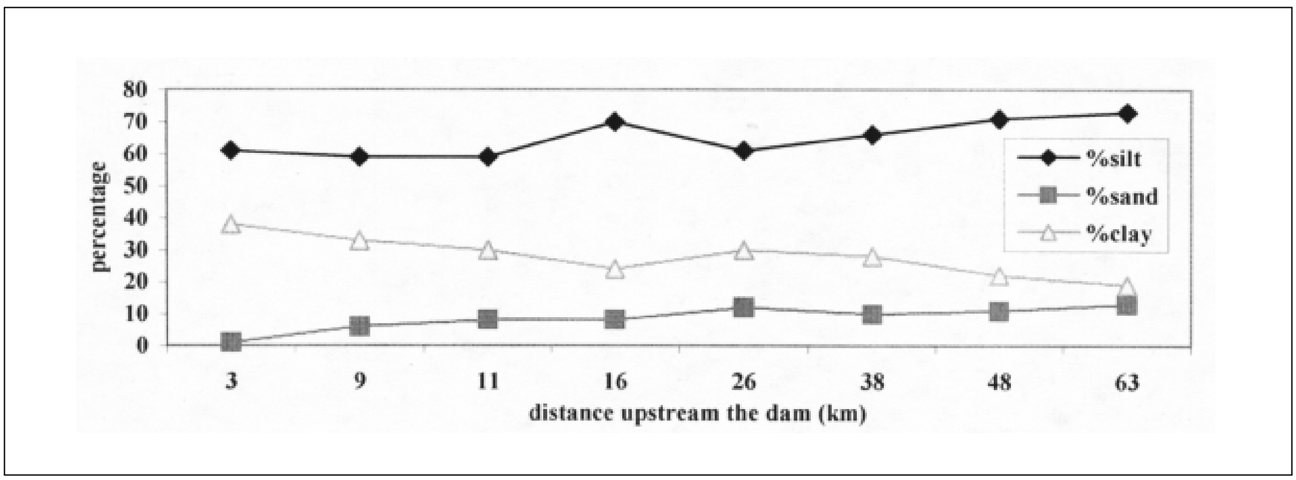

Figure 5. Distribution of silt, sand and clay percentages in the bed material in the reservoir.

value of 0.009 mm. The D_{90} ranges between 0.01 mm near the dam to 0.2 mm at a distance of 22 km upstream of the dam with an average value of 0.06 mm. The three percentages of the particle size (D_{16}, D_{50}, and D_{90}) represent the same trend in the reservoir, where they mainly decrease downstream toward the dam and also decrease in the upstream part of reservoir near the confluence area between the river and reservoir.

Figure 7 shows the distribution of D_{50} of the bed material in the reservoir represented by isocontour lines. The homogeneity of the surface bed material of the reservoir, which can be predicted by using the geometric standard deviation of the material ($s = (D_{84}/D_{16}) \times 0.5$) gave an indication that the bed material of the reservoir is more homogenous at the upper and lower parts of the reservoir than the middle part as shown in Figure 8. At the same time the average degree of homogeneity of the bed material of the reservoir is about 18% of the total reservoir area.

Finally the detail areal distribution of the bed sediment components (clay, silt, sand) samples is shown in Figure 9. The dominant sand percentage in the reservoir bed is (10-30) and followed by a lower percentage of silt (50-70) and a maximum portion of clay (>20%).

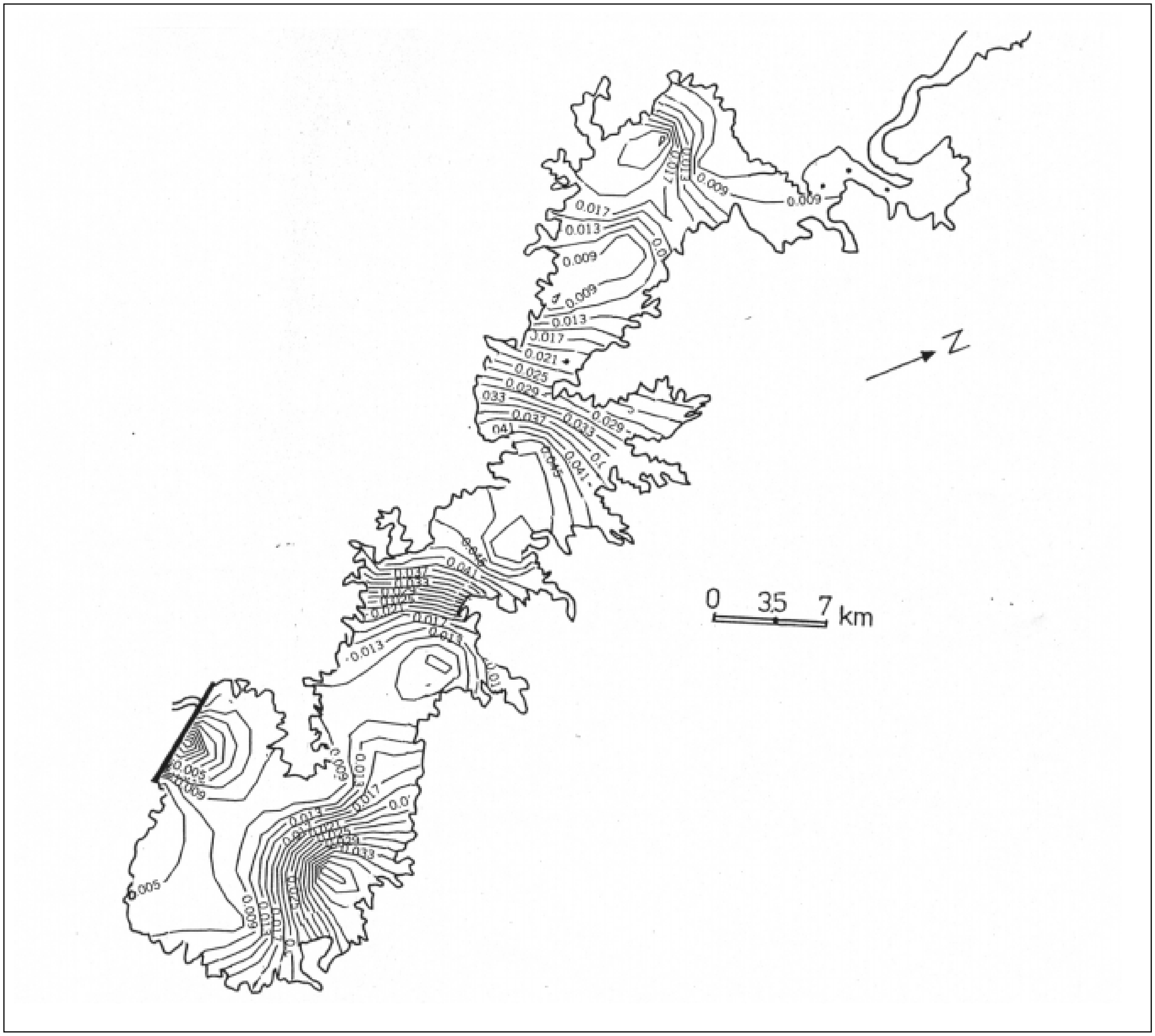

Figure 7. Iso contour line for the D_{50} of the bed sediment of Mosul Dam reservoir.

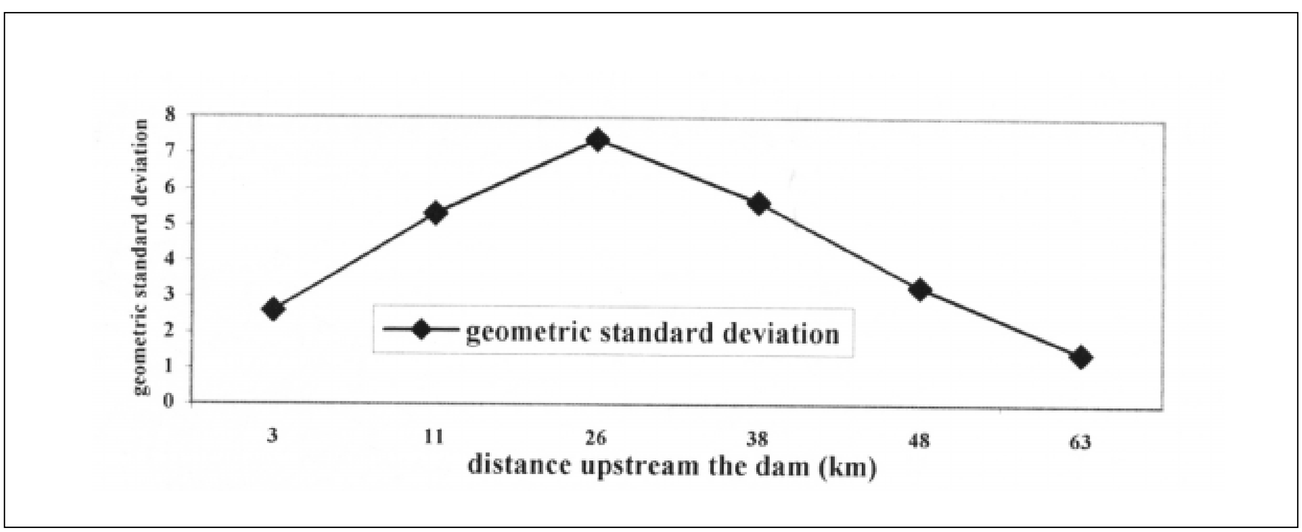

Figure 8. Geometric standard deviation for the bed material of Mosul dam reservoir.

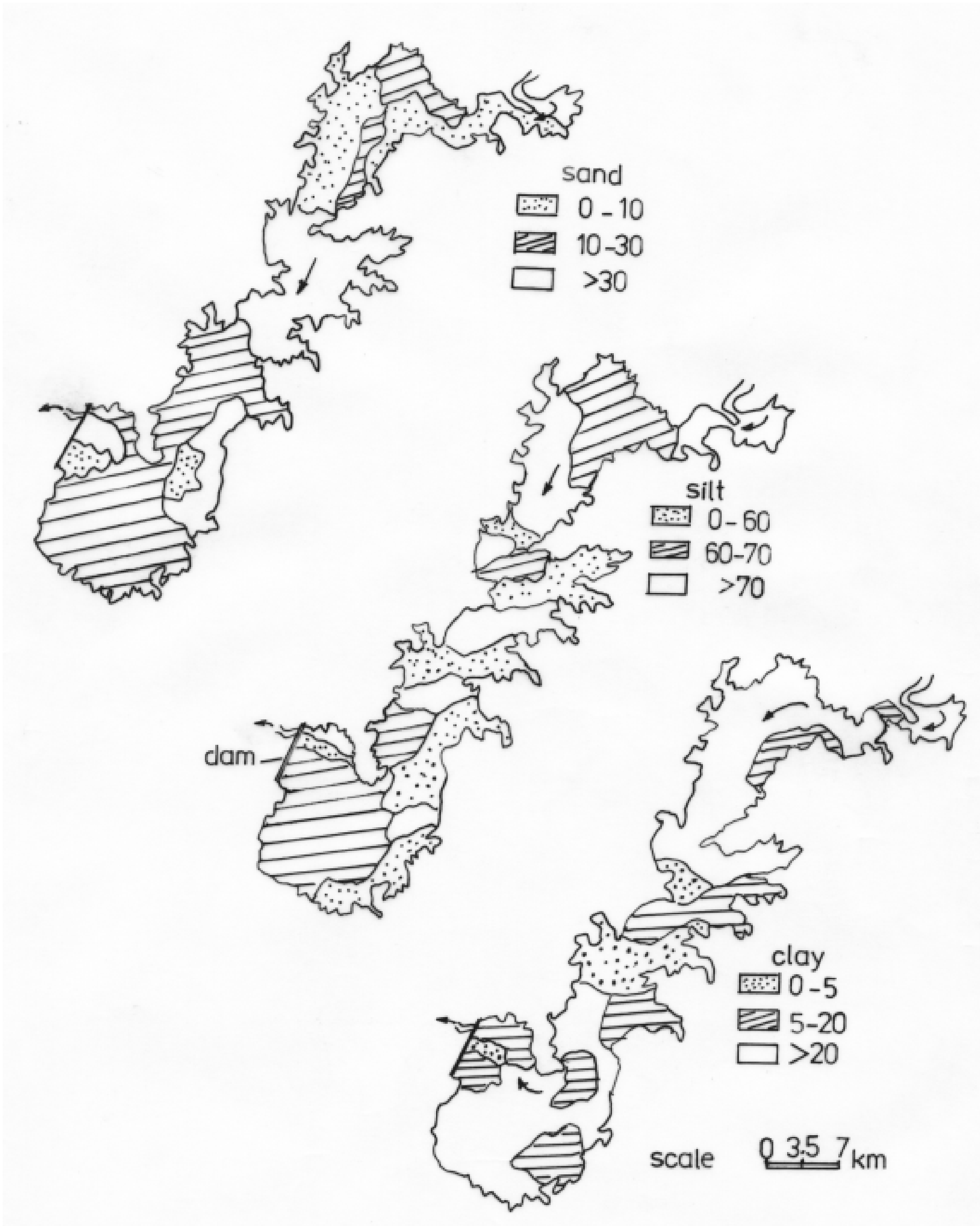

Figure 9. Areal distribution of sand, silt and clay within the bed sediment of the studied reservoir.

CONCLUSIONS

The dominant fraction of the surface bed sediment in Mosul reservoir is silt (64.8%) followed by sand (19.6%) and clay (15.6%). Furthermore, according to the classification in this research work, the dominant range of bed sediment components along the reservoir were 10% to 30% sand, 50% to 70% silt and 20% clay.

The bed sediment samples near the dam have the finer particles than the other samples along the reservoir. In other words, the percentage of clay in the bed sediment increased from the upstream reach of the reservoir downstream toward the dam. While the silt and sand percentages decreased toward the dam, some of the fine clay particles remain in suspension as a density current, especially within the submerged riverbed. The D_{16}, D_{50}, and D_{90} values decreased toward the dam and they decreased a small percentage toward the upstream reach of reservoir near the confluence area between the river and reservoir.

The average value of D_{16}, D_{50}, and D_{90} of the bed sediment were 0.0025, 0.009 and 0.06 respectively. Finally the average value of the degree of the homogeneity of the surface bed material for the reservoir is about 18% of the total reservoir area.

REFERENCES

Al-Taiee,T.M. 1993. The effect of storage capability of Mosul reservoir on the downstream Tigris river flow regime. Scientific Journal of Water Resources, Vol.2, No.1. Ministry of Irrigation. Baghdad, Iraq.

Al-Taiee, T.M. 1990. The influence of a dam on the downstream degradation of a river bed : case study of the Tigris River, Proceedings of the International Conference on the Hydrology of Mountainous Regions. Switzerland.

Borland, W.M., and S.P. Miller. 1957. Distribution of sediment in large reservoirs. Proceeding, ASCE, Vol. 84, Hyd2.

Folk, R.L. 1954. The distinction between grain size and mineral composition in sedimentary rock nomenclature. Journal of Geology 62 (4), 344-359.

Sly, P.G. 1978, Sedimentary processes in lakes. *In* Lerman, A. (ed.), Lakes: Chemistry, Geology, Physics: New York, Springer-Verlag, 363 p.

UNESCO. (1985). Methods of computing sedimentation in Lakes and Reservoirs. UNESCO, Paris.

Vanoni, V.A. 1977. Sediment engineering manual on engineering practice. Amer. Soc. Of Civil Eng. Manual and reports on engineering practice. No. 54. New York. 745p.

Vetter, C.P. 1953. Sediment problem in Lake Mead and downstream on the Colorado River. Transactions of the Amer. Geophysical Union, Vol.34, No.2.

Thair Mahmood Al-Taiee
Assistant Professor
Research Center for Environment and Water Resources
Mosul University
Mosul, Iraq

Email:thairaltaiee@yahoo.com