# Distribution of Sediments in the Reservoir by Area Reduction Method

**P. P. Mahadik, P. T. Nimbalkar, R. H. Jadhav**

**Abstract:** ***The repository of water for irrigation, water supply and power generation or for moderation of floods necessitates the construction of dams across rivers. As a consequence of the reduced velocity upstream of the dam all the bed load and a part of the suspended load is deposited in the quiet pool of water in the reservoir. This reduces the capacity of the reservoir for storing water by depositing the sediment in therein. There are two main methods of forecast of sediment distribution are area reduction method and area increment respectively. For the prediction of Sediment distribution in dam's reservoir we can use the area reduction method & by using the Borland and Miller method finding out its parameters (C,m,n).the main objective of Borland and Miller technique is to determine depth/capacity /surface area relationship for reservoir once sediment has been deposited in this.***

***Index Terms: Reservoir Sedimentation, Area Reduction Method, Nira Devghar Dam.***

## I. INTRODUCTION

As early as 4000 BC people built dams across rivers to store water, built canals for navigation purposes and also to carry water to the fields to produce much needed food. Together with the problems associated with the problems of flood control and the irrigation works. More complicated problems are encountered in modern times because, with the increase in population, more and more rivers are being harnessed for multipurpose use-flood control, water supply. Power generation, irrigation and navigation for which artificial changes are being made in the water courses. These problems have become complicated because of the fact that rivers and other water courses, in most cases, run through loose material and the water; carries some of this material along with it. The presence of sediment in water also creates problems in the operation of turbines and pumps. Further the money spent in treating the water to remove sediment and make it fit for domestic or industrial consumption is enormous.

The loose non cohesive material through which a river flow is generally called sediment and the subcommittee on Sediment

Terminology of the American Geophysical Union has accepted the following definition given by the New Standard Dictionary: Fragmental material transported by, suspended in, or deposited by water or air, or accumulated in the beds by other natural agents; any detritus accumulation, such as loess. Sediment is also sometimes known as alluvium. The branch of engineering which deals with rivers and canals flowing through loose transportable material (sediment or alluvium) and transporting some of it along with water is called fluvial hydraulics, sediment engineering or alluvial river dynamics.

Sediment engineering deals with nature of sediment problems, detailed study of sediment deposition in reservoir, distribution of sediments. For sediment deposition and distribution area reduction method is used. Area reduction method gives sediment distribution at different elevation

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## II. METHODOLOGY

In 1958, Borland & Miller was elaborated exact area reduction method. On the basis of relationship between depth of reservoir & the volume of reservoir determines the type of reservoir. In this technique types of reservoir are classified on the basis of different values of parameter "M" & its speaks to the mutual of slope (n) obtained from plotting depth of reservoir on y-axis vs. volume on x axis graph on log -log paper as shown in fig. following tables shows the classification of reservoir.

**I. Classification of Reservoir**

| Standard classification | Reservoir Type | "M" |
|---|---|---|
| I | Lake | 3.5-4.5 |
| II | Flood plain –foothill | 2.5-3.5 |
| III | Hill | 1.5-2.5 |
| IV | Gorge | 1.0-1.5 |

## III. STUDY AREA

**A.** *Nira Deoghar is an earthfill dam on Nira waterway close Bhor, Pune locale in the*

territory of Maharashtra in India The Nira Devghar dam is situated on Nira stream in Pune district of geographical area in India inbuilt 2008.the catchment area of river at dam site is 1430.5090km2, length of the dam is 2330 m & its volume 337.390 million m3 & full reservoir lengths is 667.100 m respectively. The main purpose of dam for irrigation, beverage provides also it is employed for hydro power generation. The water spread area at the time of impoundment at FRL 667.1 m

was 1430.905 Mm2 and corresponding capacity was 337.900 Mm3, and that at MDDL 626 m was 135.01 Mm2, and corresponding capacity is 5.2647 Mm3.

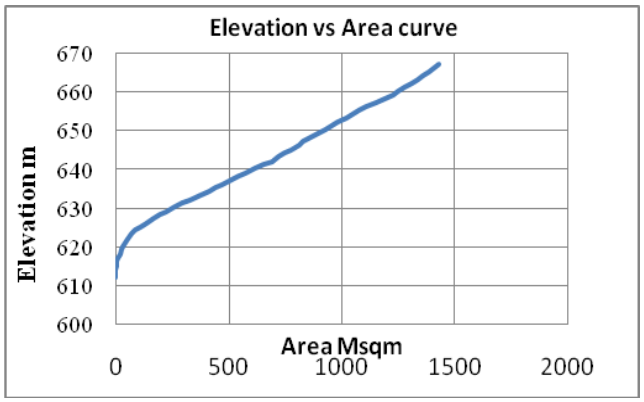


**Fig. (1): Elevation Area Curve for Nira Deoghar Reservoir for the Year 2008**

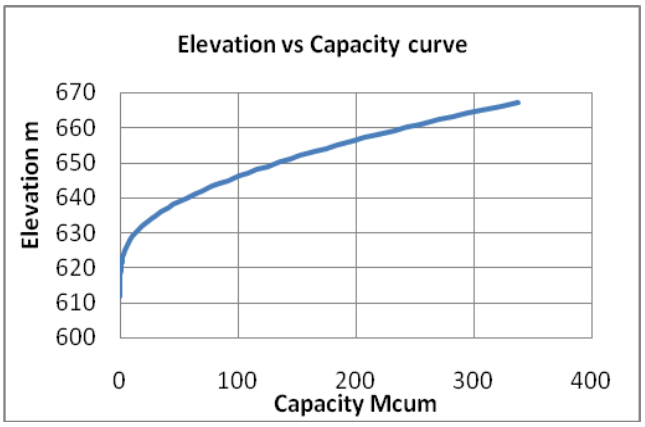


**Fig. (2): Elevation- Capacity Curve for Nira Deoghar Reservoir for the Year 2008**

## IV. DATA ANALYSIS

Nira Deoghar reservoir is selected as a study area for valuation of sediment distribution at different levels. The type of deposition pattern of Nira Deoghar reservoir is defined from linear slope of depth capacity curve on log scale by getting reciprocal of slope (M).Fig 1, Fig 2 shows the depth-capacity-area curve for Nira Deoghar dam.as per the table no.1 the Nira Deoghar reservoir falls under type III (Hill).

For defining sediment distribution type the following procedure must be followed step by step in area reduction technique.

I) for the defining reservoir type we can find out shape factor M from the log depth vs log capacity relation drawn on logarithm paper.

II) Determining different values of relative depth P, It can be calculated by dividing depth above bed at any elevation to total depth at dam FRL.

III) Then using relative depth calculate relative sediment area factor ‘p’ by putting values of relative depth in equation relating to reservoir type. After siltation assume that new bed level (ho) close to the dam & estimate the values of reservoir area, storage capacity, and relative depth and factor ‘Ap’ at level ‘ho’.Calculte the “K” as sediment area at level (ho) to Ap at new bed level & Relative area is calculate form the formula

$$a_{(p)} = Cp^{m}(1-P)^{n}$$

IV) According to the type of reservoir the fixed coefficients C, m and n are determined from Table no. II

**II. Fixed Coefficients C,M,N**

| Types | C | M | N |
|---|---|---|---|
| I | 5.074 | 1.85 | 0.36 |
| II | 2.487 | 0.57 | 0.41 |
| III | 16.967 | -1.15 | 2.32 |
| IV | 1.486 | -0.25 | 1.34 |

V) computation of reservoir data from collected data for year 2008 And 2019,we can calculated total silt deposited in last 11 years and plot sediment deposition curves for dam for the year 2019 and plot revised area elevation capacity curve. We can calculate loss of gross storage and predict elevation capacity for different years by using area reduction technique.

## V. RESULT ANALYSIS

In Area reduction methodology earlier year's elevation– area– limit curves are utilized thus on ascertain deposit circulation. During this this examination by utilizing information of the year 2008 elevation– capacity– territory curves of Nira Devghar dam and through Area reduction methodology, the silt deposition profile was evaluated for the year 2019. From the profundity limit relationship, Nira Devghar Dam is under the type III repository class. for the year 2008 to year 2019 total sediment went into Nira Devghar dam is 1203.3215 Ha-m. The present examination uncovers that gross storing limit of the dam is diminished by 120.33Mm3 which is about 35.6% of all out limit. The rate normal yearly loss of limit was 3.23%. After sedimentation net storing limit of the dam is 211.817Mm3.

The state of the dam is characterized by the depth vs capacity relationship where "M" is the reciprocal of slope calculated from depth versus capacity plot on a logarithmic paper (USBR 1962). Taking into account that M = 2.3142, the reservoir is from type III(Hill).

The measure of silt and its deposition, the reservoir was projected for the years 2019, 2021,2023,2025,2026. That is 50 % of volume of Nira Devghar dam will be filled by silt in 2026.



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**III.Sediment Computation By Area Reduction Method**

| RL(m) | volume Ha-m (2019) | Area Ha(2019) | Relative depth | Ap for type III | Sediment area Ha-m | Sediment volume Ha-m | Accumulated sediment volume | Revised Area Ha | Revised capacity Ha-m |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 667.1 | 3321.5 | 1430.1 | 1 | 0 | 0 | 0 | 1203.321 | 1430.1 | 2118.17 |
| 663.1 | 2767.7 | 1335.7 | 0.6666 | 0.0168 | 22.1237 | 22.1237 | 1181.197 | 1313.57 | 1586.50 |
| 659.1 | 2255.5 | 1222.6 | 0.33333 | 0.05536 | 74.2369 | 96.3607 | 1084.8369 | 1148.36 | 1170.66 |
| 655.1 | 1795.3 | 1076.1 | 0 | 0 | 107.62 | 181.856 | 902.9799 | 968.48 | 892.320 |
| 651.1 | 1388.5 | 948.1 | 0 | 0 | 94.81 | 202.43 | 700.5499 | 853.29 | 687.950 |
| 647.1 | 1032 | 831.9 | 0 | 0 | 83.19 | 178 | 522.5499 | 748.71 | 509.450 |
| 643.1 | 721 | 719.3 | 0 | 0 | 71.93 | 155.12 | 367.4299 | 647.37 | 353.570 |
| 639.1 | 460.7 | 576.9 | 0 | 0 | 57.69 | 129.62 | 237.8099 | 519.21 | 222.890 |
| 635.1 | 256.8 | 442.7 | 0 | 0 | 44.27 | 101.96 | 135.8499 | 398.43 | 120.950 |
| 631.1 | 109 | 291.7 | 0 | 0 | 29.17 | 73.44 | 62.4099 | 262.53 | 46.5900 |
| 627.1 | 18 | 166.2 | 0 | 0 | 16.62 | 45.79 | 16.6199 | 149.58 | 1.3800 |
| 623.1 | 0 | 0 | 0 | 0 | 0 | 16.62 | 0.01 | 0 | 0 |
| 619.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0 | 0 |
| 615.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0 | 0 |
| 611.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0 | 0 |

| RL(m) | Revised Area (Ha) 2019 | Revised capacity Ha-m 2019 | Sediment deposition Ha-m | Cumulative sediment volume (Ha-m) |
|---|---|---|---|---|
| 667.1 | 1430.1 | 2118.1785 | 0 | 1203.321 |
| 663.1 | 1313.57 | 1586.5022 | 22.1237 | 1181.197 |
| 659.1 | 1148.36 | 1170.6630 | 96.3607 | 1084.8369 |
| 655.1 | 968.48 | 892.3200 | 181.856 | 902.9799 |
| 651.1 | 853.29 | 687.9500 | 202.43 | 700.5499 |
| 647.1 | 748.71 | 509.4500 | 178 | 522.5499 |
| 643.1 | 647.37 | 353.5700 | 155.12 | 367.4299 |
| 639.1 | 519.21 | 222.8900 | 129.62 | 237.8099 |
| 635.1 | 398.43 | 120.9500 | 101.96 | 135.8499 |
| 631.1 | 262.53 | 46.5900 | 73.44 | 62.4099 |
| 627.1 | 149.58 | 1.3800 | 45.79 | 16.6199 |
| 623.1 | 0 | 0 | 16.62 | 0.01 |
| 619.1 | 0 | 0 | 0 | 0.01 |
| 615.1 | 0 | 0 | 0 | 0.01 |
| 611.1 | 0 | 0 | 0 | 0.01 |

**V.Loss of Gross Storage**

| Year | Reservoir capacity (Ha-m) | Loss of capacity (Ha-m) | Period Year | % loss of capacity from 2008 | % Annual loss |
|---|---|---|---|---|---|
| 2008 | 3374.1 | 0 | 0 | 0 | 0 |
| 2019 | 2118.1785 | 1203.3215 | 11 | 35.6 | 3.23 |

From the above result table it can be seen that during year 2008 to 2019 (11 years period) capacity loss is 1203.32 ha-m..the reservoir capacity of Nira Devghar Dam in the year
2019 was 2118.1785ha-m by area reduction method. The percentage loss of capacity from 2008 was 35.6 for 11 years periods and percentage average annual loss of capacity was 3.23. VI,Predicted elevation capacity for different years

| RL m | Original capacity Ha-m | Revised capacity 2019 | Revised capacity 2021 | Revised capacity 2023 | Revised capacity 2025 | Revised capacity 2026 |
|---|---|---|---|---|---|---|
| 667.1 | 3374.1 | 2118.178 | 1983.554 | 1857.485 | 1739.43 | 1683.246 |
| 663.1 | 2820.3 | 1586.502 | 1485.669 | 1391.245 | 1302.822 | 1260.74 |
| 659.1 | 2308 | 1170.663 | 1096.259 | 1026.584 | 961.338 | 930.287 |
| 655.1 | 1847.9 | 892.32 | 835.607 | 782.498 | 732.765 | 709.097 |
| 651.1 | 1441.1 | 687.95 | 644.226 | 603.281 | 564.938 | 546.691 |
| 647.1 | 1084.6 | 509.45 | 477.071 | 446.749 | 418.356 | 404.843 |
| 643.1 | 773.6 | 353.57 | 331.098 | 310.054 | 290.348 | 280.97 |
| 639.1 | 513.3 | 222.89 | 208.723 | 195.458 | 183.035 | 177.123 |
| 635.1 | 309.4 | 120.95 | 113.262 | 106.064 | 99.323 | 96.114 |
| 631.1 | 161.6 | 46.59 | 43.628 | 40.855 | 38.259 | 37.023 |
| 627.1 | 70.6 | 1.38 | 1.292 | 1.21 | 1.133 | 1.096 |
| 623.1 | 24.7 | 0 | 0 | 0 | 0 | 0 |
| 619.1 | 6.3 | 0 | 0 | 0 | 0 | 0 |
| 615.1 | 0.464 | 0 | 0 | 0 | 0 | 0 |

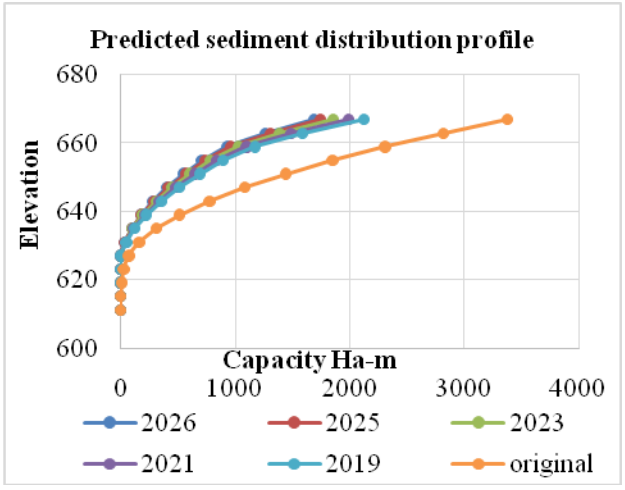


Fig. (3): Predicted elevation capacity curve for different year

## VI. CONCLUSION & FUTURE WORK

**Result shows that,**

I) Area reduction methodology is one among of the foremost applicable methodology of estimating sediments distribution at the time of dam design. This method is more reliable than area increment method.

II) The reservoir was projected for the years 2019, 2021,2023,2025,2026. The result shows that 50 % of volume of Nira Devghar dam will be filled by sediment in 2026.

## ACKNOWLEDGMENT

It is optional. The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank ... ." Instead, write "F. A. Author thanks " *Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page.*

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