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SILTATION STUDIES OF RESERVOIRS

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ABSTRACT
The most important practical and critical problem related to the performance of reservoirs is the estimation of storage capacity loss due to sedimentation process. The problem to be addressed is to estimate the rate of sediment deposition and the period of time at which the sediment would interfere with the useful functioning of a reservoir. Fairly a large number of methods and models are available for the estimation, analysis and prediction of reservoir sedimentation process. However, these methods and models differ greatly in terms of their complexity, inputs and computational requirements.

Key Words: - Siltation, Storage, Reservoir, Dam, River, Canal, Flow, Erosion, Sediment etc.

DAMS AND RESERVOIRS
Dams and Reservoirs are the most significant storage structures that have improved irrigation facilities in India. Improvement in the irrigation has lead to food security. In the last century there is noteworthy development in construction of reservoirs all across the world.

Reservoirs are the storage structures that exists upstream of a dam constructed across a river with the intention to store water during period when river has excess water flowing through it and use it in the dry period or the time when river has less water. The construction of dam has many advantages like power generation, irrigation facilities through canal.

SEDIMENTATION
Rivers along with water takes with it large amount of sediments due to soil erosion from banks and beds. The construction of dam causes an obstruction to the flow of sediments through it and leads them to settle in its upstream side. Reservoir sedimentation causes a consequent loss of storage capacity of the reservoir. It also affects reservoir function, such as control of flood, supply of water, irrigation facilities, navigation facilities, electricity generation, etc. In dry regions, reservoir sedimentation become quite intense where the loss of active storage capacity is above 1 - 2 % per year and the lifetime of most reservoirs gets reduced by 20 to 30 years.

THE EFFECTS OF SEDIMENTATION
The construction cost of dams and reservoirs is very huge and a large area is under submergence because of formation of reservoirs causing loss to flora and fauna of that area. The deposition of sediment in reservoirs sometimes affects the functioning of water intake structures and can create problems from the machinery point of view. The silt from the reservoir if not taken care of will flow into the canals and may deposit there thereby creating problems in the canal system causing over spilling conditions in the canals. The large amount of water stored in the reservoirs is used for supply of water in dry seasons, electricity generation and irrigation purpose, navigation and recreational purpose.

The sedimentation process in reservoirs increases the water turbidity in reservoirs that results to the environment problems for example it deteriorates the water quality and reduces the visibility for fish.

OBJECTIVES OF THE PRESENT STUDY
The objectives of the present study are
- To determine the trap efficiency of Bhadra Reservoir using different methods
- To determine the trap efficiency of Upper Kolab Reservoir using different methods

- To determine the trap efficiency of Panchet Reservoir using different methods
- To determine the trap efficiency of Idamalayar Reservoir using different methods
- To do a comparative study among different methods in assessing the trap efficiency of reservoirs.

REVIEW OF LITERATURE

STORAGE LOSS OF RESERVOIRS

The reservoir sedimentation causes a continuous decrease in the active storage capacity of the reservoirs this also reduces the useful life of the reservoir. Studies around the globe tell about the harm caused by the reservoir sedimentation.

The Indus River takes with about 74 billion cubic meters of water and the river also carries about 300 million tons of sediment annually into the Tarbela Reservoir. The Tarbela reservoir was opened in 1974, within six years of its construction it accumulated nearly 950 million cubic meters of sediment and gets deposited in the upper thirty kilometres of delta (Wu et al 1991).

TRAP EFFICIENCY OF RESERVOIRS

The Trap Efficiency (TE) is the ratio of sediment trapped in the reservoir to the sediment inflow. It is very important aspect as per the design of reservoirs as it affects the useful life of reservoirs.

USEFUL LIFE OF RESERVOIR

The useful life span of a reservoir is the time period for which water storage gives beneficial outputs. The sedimentation of reservoir and its useful life are also influenced by the pattern of inflow and the characteristics of catchment.

COMPARATIVE STUDIES OF DIFFERENT METHODS OF TRAP EFFICIENCY

Bube and Trimble (1986) revised the curves proposed by Churchill (1948) by using the Churchill (1948) data and the data added by Borland (1971). They further revised the curves by using an optimization technique in that they decreased local sediment yields variance that is given by these curves.
Trimble and Carey (1990) made a comparison between the Churchill (1948) method and the Brune (1953) method based on the data collected from 27 reservoirs in the Tennessee River Basin. The results shows that the values of trap efficiency calculated using Brune's method were equal to or more than the value of trap efficiency calculated by Churchill's method. The results concluded that the Churchill method gives more realistic results as compared to that of Brune's for sediments yields for a system of reservoirs.

Butcher et al. (1992) measured the sediment in inflow and outflow for two reservoirs in southern Pennines, UK. They performed a comparative analysis between the trap efficiency observed and the trap efficiency calculated using Brown′s method, Churchill′s method, Brune's curve and Heinemann′s curve. The results of all the methods were quite reasonable and close to the observed trap efficiency. Brown′s method was concluded to be the most accurate among all because the reservoirs in this study had the same hydrologic regime as the reservoirs used by brown in his study. The brown′s curve uses two parameters capacity and catchment area, hence this method is simple to use.

According to Rowan et al. (1995) for Abbystead Reservoir, UK, the trap efficiency values determined from Heinemann (1981) method was 30% lower than that calculated by Brown (1944) method. The value of trap efficiency calculated from Brune (1953) method comes out in between the values obtained from other two methods.

Taher-Shamsi and Sabzivand (1999) did a comparative analysis of three different methods of calculation of trap efficiency. They used the data of various reservoirs in Iran. According to the results, the value of trap efficiency calculated from the brune′s curve and brown′s method were closer to the measured value in the field. However the Churchill′s method overestimated the value of trap efficiency as compared with field data. Rao (2018) made a study of Krishnagiri Reservoir, Tamil Nadu and according to his results the value of trap efficiency calculated

using Gill′s method is found to be closer to the measured value of trap efficiency. The dominant particle size of sediment in the reservoir was fine grained. The values of trap efficiency calculated for the reservoir ranges from 64.99% to 95.31%. The useful life of the Krishnagiri reservoir has been predicted to be 101 years.

METHODOLOGY

BRUNE'S CURVE

The brune′s method (1953) is the most widely used method of determining the trap efficiency for estimating the reservoir sedimentation. Brune (1953) developed a curve between trap efficiency and the capacity- inflow ratio by taking the data from 44 normally ponded reservoirs in USA. It gives reasonable values of trap efficiency and also simple to use, only uses capacity and average annual inflow hence making it the most commonly used method for the calculation of trap efficiency. Brune developed three curve′s one as the median curve and two envelope curves.

GILL'S METHOD

Gill in 1979 developed empirical equations for all the three curves of brune′s method as a better fit.

BROWN METHOD

Brown in 1944 developed the first method for calculating the trap efficiency of reservoirs by developing a curve having relationship between trap efficiency and the ratio of capacity of reservoir and the watershed area upstream of dam.

HEINEMANN METHOD

Heinemann (1981) developed a new method for the calculation of trap efficiency with little variation from Brune's curve taking data of 20 agriculturally ponded reservoirs in the USA. The sizes of the reservoirs from where the data have been taken were having the size range as 0.8 to 36.3 Km^2. According to Heinemann (1981) the value of trap efficiency predicted using his method comes out lesser than that of brune's curve. The Heinemann method has restrictions to its use since it was developed taking data from small size reservoirs.

DENDY'S EQUATION

Before Brune's curve was developed, capacity-watershed area ratio was used for calculation of trap efficiency instead of capacity-inflow ratio. After the development of Brune′s curve, capacity-inflow ratio is used. Dendy suggested another equation by taking data of 17 more small size reservoirs ($A \leq 60$ km2) to Brune′s curve. Likewise Heinemann method this method also offers restrictions because of the small size of reservoirs taken for study.

JOTHIPRAKASH AND GARG METHOD

Vinayakam Jothiprakash and Vaibhav Garg (2008) developed equations for the estimation of trap efficiency using brune′s curve (1953) for predominantly coarse grained sediment and medium grained sediment sizes. They determined the trap efficiency of Govindsagar reservoir, Himachal Pradesh, India using the brune′s and brown′s method and compared them with new set of equations developed after the regression analysis performed for the brune′s method and compared it with the brown′s method. According to the results, the new set of equations gives the results better than the other equations reported in the literature.

RESULTS AND DISCUSSIONS

TRAP EFFICIENCY

The trap efficiency of different reservoirs is determined through various methods available such as brune′s method, gill′s method, Brown′s method, etc. Sediment type to be adopted (coarse, medium and fine) depends on the dominant size of particles in the inflowing water determined through soil analysis. The trap efficiency calculated in our project is single event trap efficiency. The capacity of different reservoirs and the mean annual inflow has been taken from the capacity survey reports provided by the central water commission. The capacity-

inflow ratio is used for the calculation of trap efficiency in all the methods except brown method which uses the capacity- watershed area ratio for determination of trap efficiency.

BHADRA RESERVOIR

RATE OF SILTATION

Capacity Corresponding to FRL as per pre-impoundment survey 1964 = 2025.87M.Cu.m
Capacity corresponding to FRL as per 2011 survey = 1930.125M.Cu.m
Silting in 47 years = 95.745M.Cu.m
Annual siltation = 2.037M.Cu.m/YR
Rate of siltation =10.35 ha.m/100sq.km/year

UPPER KOLAB RESERVOIR

RATE OF SILTATION

Capacity Corresponding to FRL as per pre-impoundment survey 1986 =1215.00 M.Cu.m
Capacity corresponding to FRL as per 2011 survey =1073.95 M.Cu.m
Silting in 25 years =141.05M.Cu.m
Annual siltation = 5.642M.Cu.m/YR
Rate of siltation = 34.61 ha.m/100sq.km/year

PANCHET RESERVOIR

RATE OF SILTATION

Capacity Corresponding to MWL as per pre-impoundment survey 1956 =1580.94 M.Cu.m
Capacity corresponding to MWL as per 2011 survey =1193.46 M.Cu.m
Silting in 55 years = 387.48M.Cu.m
Annual siltation =7.05M.Cu.m/YR
Rate of siltation =8.00 ha.m/100sq.km/year

IDAMALAYAR RESERVOIR

RATE OF SILTATION

Capacity Corresponding to FRL as per pre-impoundment survey 1986 =1208.23 M.Cu.m
Capacity corresponding to FRL as per 2011 survey =1176.187 M.Cu.m
Silting in 25 years =32.043M.Cu.m
Annual siltation =1.282M.Cu.m/YR
Rate of siltation =26.60 ha.m/100sq.km/year

CONCLUSIONS

The trap efficiency of four reservoirs namely Bhadra reservoir, Upper kolab reservoir, Panchet reservoir and Idamalayar reservoir has been determined in this thesis using different methods. The different methods used for the determination of trap efficiency of above reservoirs are Brune's curve, USDA-SCS equations, Dendy's method, Brown's curve, Gill's method and Jothiprakash and Garg method.

The trap efficiency of Bhadra reservoir(Karnataka) having rate of siltation 10.35 ha.m/100sq.km/year has been found out to be 96% according to brune's curve, 93.26% according to Heinemann's curve, 96.88% according to USDA-SCS equations, 96.063% according to Dendy's method, 99.51% according to brown's curve, 96.37% according to Gill's method, 97.93% according to Jothiprakash and Garg method.

The trap efficiency of Upper Kolab reservoir(Odisha) having rate of siltation 34.61 ha.m/100sq.km/year has been found out to be 95.5% according to brune's curve, 92.985% according to Heinemann's curve, 96.749% according to USDA-SCS equations, 95.67% according to Dendy's method, 99.27% according to brown's curve, 96.14% according to Gill's method, 97.656% according to Jothiprakash and Garg method.

The trap efficiency of Panchet reservoir(Jharkhand) having rate of siltation 8.00 ha.m/100sq.km/year has been found out to be 80% according to brune's curve, 76.166% according to Heinemann's curve, 80.7% according to USDA-SCS equations, 79.43% according to Dendy's method, 84.65% according to brown's curve, 82.078% according to Gill's method, 81.86% according to Jothiprakash and Garg method.

The trap efficiency of Idamalayar reservoir(Kerala) having rate of siltation 26.60 ha.m/100sq.km/year has been found out to be 96.8% according to brune's curve, 93.67% according to Heinemann's curve, 96.987% according to USDA-SCS equations, 96.657%according to Dendy's method, 99.8% according to brown's curve, 96.71% according to Gill's method, 98.335% according to Jothiprakash and Garg method.

As it can be seen from the results that the trap efficiency values calculated using Heinemann's curve and Brown's curve differ from the values calculated from the other methods. The reason behind the variation in Heinemann′s curve is because of the fact that it is developed using the data of small ponds while in our case the size of reservoirs is quite large. All the methods used above except Brown's method uses the relationship between capacity and inflow for the determination of trap efficiency. However Brown's method relates the trap efficiency with the ratio of capacity of reservoir and watershed area, therefore the variation in the results of Brown's method is attributed to this factor.

REFERENCES

1. Brown C.B. (1944) "Discussion of Sedimentation in Reservoirs". Proceedings of the American Society of Civil Engineers, edited by J. Witzig, 69, pp. 1493-1500.

2. Churchill, M. A. "Discussion of 'Analysis and Use of Reservoir Sedimentation Data", Proceeding of Federal Interagency Sedimentation Conference, edited by Gottschalk, L. C., Denever, USA, pp. 139-140, 1948.

3. Brune, G. M. "Trap efficiency of reservoirs", Transactions of the American Geophysical Union, Vol. 34, No. 3, pp. 407-418, 1953.

4. Borland, W. M. "Reservoir Sedimentation in: River Mechanics", edited by Shen, H. W., Chapter 29, Forth Collins: Water Resources Publication, 1971.

5. Dendy, F. E. "Sediment Trap Efficiency of Small Reservoirs", Trans. of ASAE, Vol. 17, No. 5, pp. 898-988, 1974.

6. Rausch, D. L. and Heinemann, H. G. "Controlling Reservoir Trap Efficiency", TRANSACTIONS of the ASAE, Vol. 18, No. 6, pp. 1105-1113, 1975.

7. Gill, M. "Sedimentation and Useful Life of Reservoirs", Journal of Hydrology, Vol. 44, pp. 89-95, 1979.

8. Heinemann H.G. (1981) "A New Sediment Trap Efficiency Curve for Small Reservoirs'', Water Resources Bulletin, 17(5).

9. Garde, R.J. and Raju, K.G. (1985) "Mechanics of Sediment Transportation and Alluvial Stream Problems". 2nd Edition, Wiley Eastern Limited.