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STUDIES ON THE MANAGEMENT OF SEDIMENT CHARACTERISTICS OF VAIGAI RESERVOIR

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Abstract: *The present study deals with the management of sediment characteristics and accumulation in the Vaigai reservoir situated in Theni District, Tamil Nadu, India. Data were obtained on the texture of sediments (Sand, Silt and Clay) in four different zones namely free flowing water, Top set water, fore set water and bottom water of the reservoirs during the different seasons (Premonsoon, Monsoon, Summer and Winter) of the year 2012. Distribution of sediments and grain size analyses were also investigated in the samplings collected once in a month throughout one year, January 2012 to December 2012. Based on sediment samplings collected from the four zones, sediment characteristics and relative abundance of grains in percentage were understood. Such investigators help in the management of Vaigai reservoir to gather with the useful information needed for agriculture and drinking water for human life.*

Key Words: *Vaigai Reservoir; sustainable sediment management; Sediment characteristics; Geomorphic zones; sediment Loads.*

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INTRODUCTION

Rivers are open ecosystems and most natural rivers are characterized with respect to sediment inflow and outflow. Sediments carried into a reservoir may deposit throughout its full length, thus gradually raising the bed elevation and causing aggradations. Reservoir sedimentation is a complex process that varies with watershed sediment production, rate of transportation and mode of deposition. Reservoir sediment depends on the following parameters:

(a) River regime
(b) Flood frequencies
(c) Reservoir geometry and operation
(d) Flocculation potential
(e) Sediment consolidation
(f) Density currents and
(g) Possible land use changes over the life expectancy of the reservoir

Sediments can enter and obstruct intakes and greatly accelerate abrasion of hydraulic machinery, thereby decreasing its efficiency and increasing maintenance costs.

SUSTAINABLE SEDIMENT MANAGEMENT:

The importance of sediment management has increased, as the number of dams and their ages increase. Regarding the above complex phenomena, the necessities for sediment management of reservoirs, in general can be summarized below:

I. It prevents reservoir regimentation from burying water intakes or outlets and causing harmful riverbed aggradations directly upstream of reservoirs, thereby guaranteeing safety of river and darn management.
II. It maintains the storage functions of the reservoir to achieve sustained management of water resources for future generations
III. As a key to integrated sediment management of sediment routing systems, reservoirs must be able to discharge sediment.

INTEGRATED SEDIMENTATION MANAGEMENT

This paper deals with the general concept of reservoir sedimentation in Vaigai reservoir and management measures taken during the year 2012. Reservoir sedimentation is a complex phenomenon from sediment yield to transport and deposition within reservoirs. The

seriousness of sedimentation and necessities for counter measures are different in each reservoir or each river basin. Not only for tacking the traditional problems related to reservoir sedimentation, integrated sediment action should be considered both for sustainable management of water resources and sediment flow in the entire watershed. Reservoir sedimentation is of the most crucial issue to be solved this century for sustainable water resources management. 'Do it now and do it quick' (Bruk, 1996) is the proverb to practice and this idea has been favoured by several workers on sedimentation management of reservoir worldwide.

RESERVOIR SEDIMENTATION STORAGE AND LOSS

Reservoir sedimentation is based on hydrologic, geologic, topographic and geographic characteristics and existing reserving world meet these criteria with few exceptions in some parts of the world. In addition, the possibilities of constructing new reservoirs are becoming increasingly limited were to physical, social and environmental factors.

The annual sediment yield being deposited into the existing reservoir verses worldwide over range from 20 to 5000Km³/km², with a world average of about 100Km³/km², current gross storage capacity in the world is 5980 Km³/km², and total storage loss and annual sedimentation rate are about 567/km2 (11.8%) and 30.58/Km2 (0.52%) respectively (Figure 1).

RESERVOIR SEDIMENTATION PROCESS

Rivers are typically considered in terns of the flow and movement of water though catchments providing a hydrological link in between precipitation in the mountain areas with discharge and flooding in the flood plains (Figure 2.) however, underlying the hydrological cycle is an equally important energy cycle. From an energy point of view, the river system can be considered as a continuous process of energy conversion, where the potential energy water embodies at the top of the continuous and river channels.

During transport, some kinetic energy is dissipated as work as work as the water moves through the catchments and river tributaries or channels. Sustainable sediment management passes the entire fluvial sediment system consisting of watershed, river reservoir and dam. It is not achieved without cost. As a minimum, it involves better information and improved management but it may also include large operational and capital costs for watershed management, the construction or low-level outlets or bypass works,

temporary removal of dams from service for sediment management activities, release of increased volumes of water downstream for sediment discharge and ridging. The fact that the world's inventory of suitable reservoir sites is limited and it provides an additional reason few initiating sustainable management of dams.

MATERIAL AND METHODS

Description of the study area (Vaigai reservoir)

Vaigai reservoir is located about 70 km from Madurai and 15km from Theni. It is a reservoir on Vaigai river constructed in 1955 and completed in 1958. The reservoir is eutrophic with diverse types of sedimentary bottom. The river Vaigai rises at an altitude of about 1524 m in the Western Ghats in the Gandamanaickanur in Theni District and flows in northern direction. Vaigai reservoir is a multipurpose reservoir. The water is used for irrigation in Dindigul Madurai, Theni, Sivagangai and Ramanathapuram Districts, in addition to hydro power use and drinking water supply to Madurai city.

Vaigai reservoir has a maximum length of 315.468 m (1035 ft) Maximum width at top as roadway over reservoir 3.657m (12 ft and maximum depth of 71ft. The water spread area is 24.2015 sq.km while the water volume is 194.785mm3 (6878 mcft). The reservoir is subjected to temporal fluctuation in water volume with high water volume in rainy season and less water in the dry season due to high evaporation. The water retention time is between September and December months in the rainy season (September-November) with an average precipitation 663mm, while the water residence time in the dry season (April-July) is between March and July months with an average rainfall of about 30mm in 2012 with a total rainfall in 2012 is 397.80mm only.

VAIGAI RIVER & ITS TRIBUTARIES

The most important tributaries of Vaigai river are suruliar, Kottagudiaru (Theni aru) and Suthagangaiaru. Suruliaru rises at an attitude of 1830 (6000 ft) in the eastern ride of Western Ghats and runs nearly parallel to Vaigai river. The Kottagudiaru originates at an attitude of about 1830m (6000 ft) in Western Ghats and joins with suruliaru. The third tributary to the Vaigai river called Suthagangaiaru originates at an attitude of about 915 m (3000 ft) and joins Suruliar.

Vaigai reservoir is one of the oldest and most high profile irrigation reservoir. The Vaigai reservoir was commissioned in year 1955 after 3 years of construction and has storage of

live storage is 194.785 million cubic meter with a reservoir area of 24.201 Sq.Km. The reservoir maximum level is 279.197 meter and the minimum is 257.556 meter with reference to Mean sea level. The height of the dam is 21.64 m; it is one of the largest hydropower plant in TamilNadu.

The climate is governed by the monsoons during the rainy seasons occurring between September month and December months and the dry season months are March to May. Average Temperature at (Theni) range from a low of 30**ºC** in December month, too high 38**ºC** in May and June months. Average rainfall (at Theni) is approximately 750 mm with the highest rainfall generally occurring in the months of October and November and losses in the months of March to June. The land use across the Vaigai reservoir catchments is predominantly agricultural; However the majority of the catchment is forested and human livelihoods are primarily dependent on farming and subsistence agriculture where incomes are generally less than the national average.

METHODOLOGY ADOPTED

In order to assess the management of sedimentation within the reservoir and the normal useful operating life of the Vaigai reservoir, the following procedures were adopted.

1. Studies on Vaigai reservoir geomorphic zones
2. Data collection on texture of sediments in different zones
3. Studies on grain size analysis in different zones These studies were help to understand the management of sediment accumulation
4. Estimation of relative abundance of grains in each geomorphic zone by sieve methods.
5. Estimation of grain size distribution is the main objective in this study. Total amounts of time, medium and coarse sediments in each geomorphic zone are to be estimated
6. Volume of sediment should be correlated to the original reservoir geometry. This is used to estimate the loss of reservoirs storage volume and estimate the reservoir operating life under baseline, forestation and deforestation scenarios.

RESULTS AND DISCUSSION

GEOMORPHIC ZONES OF VAIGAI RESERVOIR

A longitudinal profile was developed for the Vaigai reservoir defaming length to be 6.4 kms upstream from the Vaigai dams site (Figure.5). Based on this diagrammatic presentation, the

reservoir is divided into four geomorphic zones. The details of each zone are presented in (Table 1).

VAIGAI SEDIMENT INFLOWS

Sediment loading to Vaigai reservoir result from a variety of sources into watershed, including agricultural and forestry practices and river run off from land drainages. A river's sediment load comprises these main components namely dissolved, suspended and bed load. Among three sediment loads, suspended load and bed load were used to estimate management of sediment flow into the Vaigai reservoir.

RELATIVE ABUNDANCE OF GRAINS

Among the three main sediment components, sedimentation management rely upon unspended load and bed loads, as far as relative abundance of grains concerned. The amount of different grains of various dimensions were determined using a sieve having different mesh size, in the following sediment components

IN SUSPENDED LOAD

Suspended load is the portion of the sediment which is carried in the body of the reservoir and sufficiently slows settling velocities that remains predominantly entered in the water column. During transport, suspension is main named by turbulence in the flowing water and consists of particles generally of fine sand, silt and clay. The distribution of sediment loads are given in percentages in the four geomorphic zones of the Vaigai reservoir (Table 2.) Sediments deposited within the reservoir will start to reduce storage capacity of the reservoir in various storage zones. The useful reservoir life is predicted as the time required for incoming sediments to fill half of the original reservoir volume and a good indication of the importance of sediment management studies.

When land degradation occurs (aggressive deforestation) in the catchments, Sediment inflow will increase reducing reservoir useful life at the upper limit of deforestation scenario, sediment inflow would average in the order of 5.6mcm/yr and under such conditions, useful reservoir life would drop to 100 years, making sedimentation a management issue with the reservoirs design, life and management would be implemented to sustain the operations efficiency of Vaigai reservoir (Figure 5).

IN BED LOAD

Bed load consists of the larger sized sediments which cannot be identified in suspension by turbulent forces in water column. Bed load sediments range from coarse sands and gravel up to boulders. These materials are transported along the river bed by salutation (i.e. sliding rolling or hopping). Unique suspended sediments and bed load can take many hydrological reasons to migrate downstream and accumulate in the river channel and then moving downstream in peak or extreme flow concerns (Table.3.)

CONCLUSION

Rivers offer the only valid components in the formation of dams and reservoirs. In the present study how the Vaigai river and its tributaries contribute the sedimentation in the Vaigai reservoir over a period of one year was identified. The importance of sustainable sediment management was reported. In addition, the reservoir sedimentation process was accounted with reference to Hydrologic, geologic, topographic and geographic features. Results on the management of reservoir sedimentation also indicated the accumulation of different types of sediments and their sources. The presence of sand silt and clay in different geomorphic zones of Vaigai reservoir play significant criteria sediment management studies. Relevant data on sedimentary grains also contribute to management of reservoirs and the reservoirs have the potential to be used as site of not only water but also sediment loads.

Table 1

Vaigai Reservoir sedimentation management parameters in Geometric zones in Percentage

S.No	Geometric zone	Sediment Parameters			
		Sand	Silt	Clay	Silt & clay (finer fraction)
1	Free flowing water	84.22	14.68	1.10	15.78
2	Top set water	76.23	22.00	1.77	23.77
3	Foreset water	81.26	14.62	2.10	15.11
4	Bottom water	91.70	16.07	1.18	25.14

Table 2. Relative abundance of grains in suspended load of Vaigai reservoir

Grain size (mm)	Zone 1 (%)	Zone 2 (%)	Zone 3 (%)	Zone 4 (%)
0.50	13.92	12.88	13.20	7.40
0.355	39.47	24.49	25.81	15.74
0.30	16.09	13.63	17.31	9.30
0.25	18.16	19.32	23.70	24.15
0.15	12.94	16.67	12.96	22.75

Table 3. Relative abundance of grains in bed load of Vaigai reservoir

Grain size (mm)	Zone 1 (%)	Zone 2 (%)	Zone 3 (%)	Zone 4 (%)
0.55	13.20	7.30	4.87	2.59
0.355	9.40	2.59	1.22	1.30
0.30	8.72	3.46	2.19	1.48
0.25	4.29	1.42	3.10	1.38
0.15	3.20	4.30	2.10	2.12

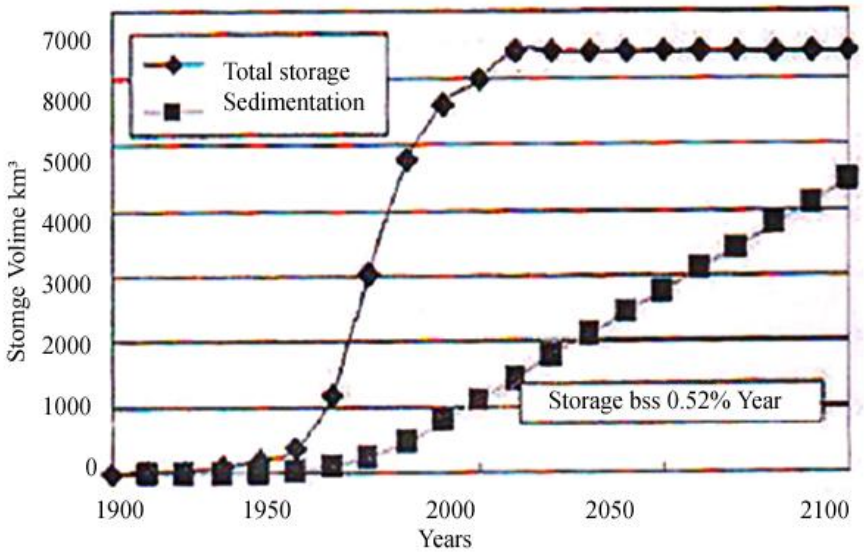

Figure 1. World storage volume and sedimentation loss

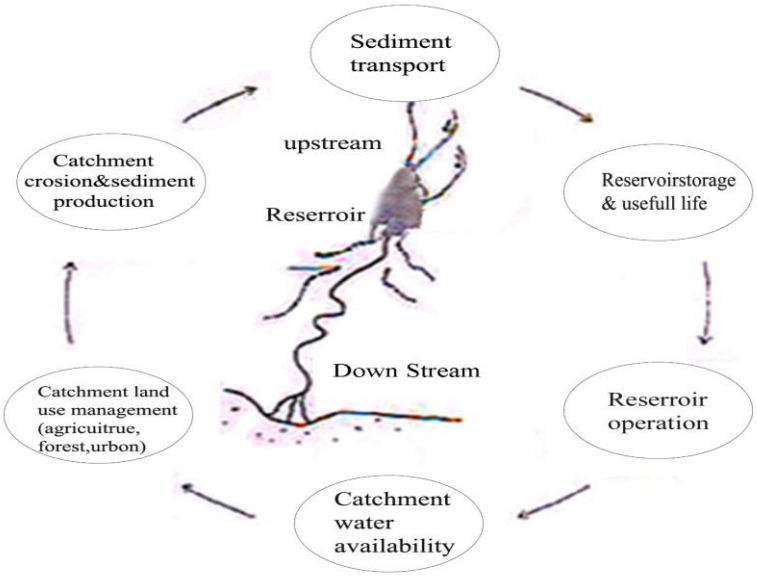

Figure 2. Sediment and hydrological transport processes in Vaigai reservoir

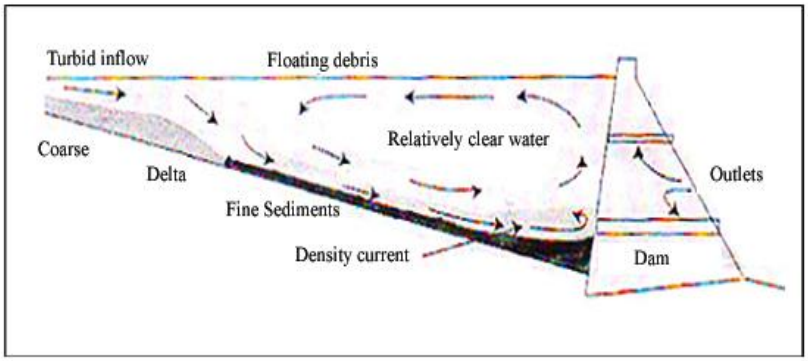

Figure 3. Vaigai Reservoir regimentation processes

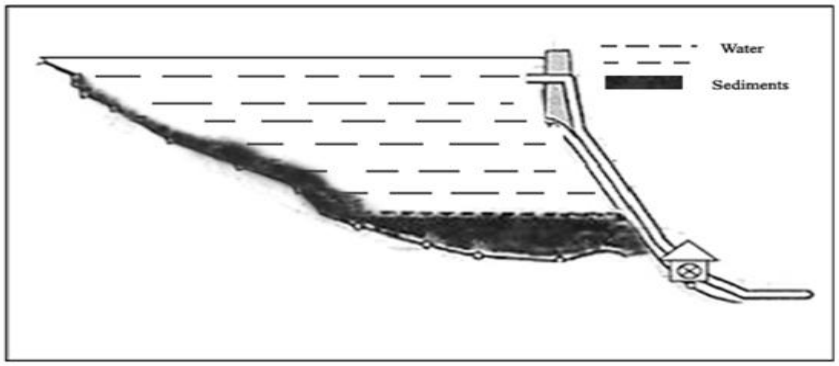

Figure 4. Profile of Vaigai reservoir Sedimentation (Sedimentation storage is shown in Dark)

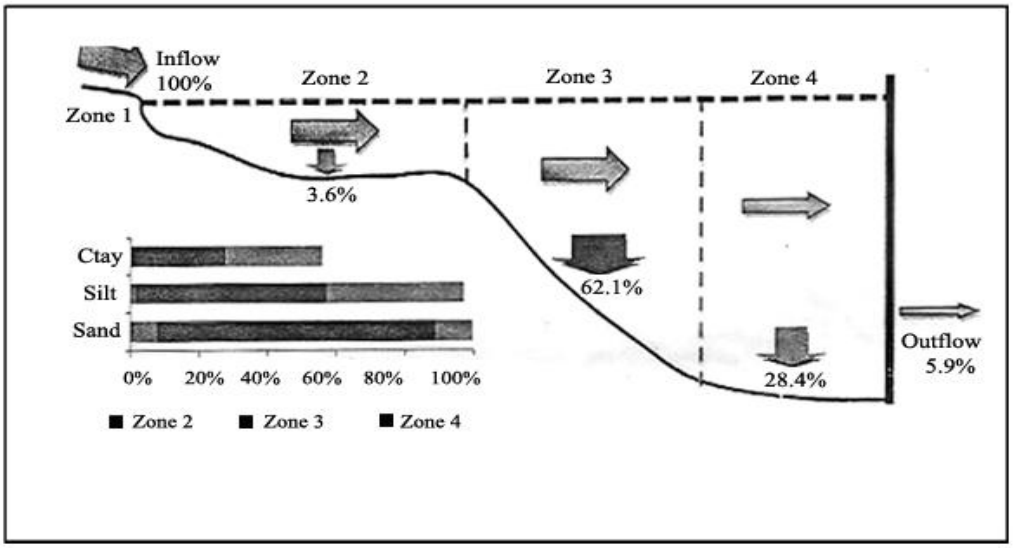

Figure .5 Sediment transport processes in different geomorphic zones of Vaigai reservoir

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