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ASSESSMENT OF SEDIMENT YIELD OF TUNGABHADRA PROJECT IN KRISHNA BASIN FROM RESERVOIR SURVEYS

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Abstract:

The water being the most important reason for the evolution of mankind on earth, is tapped and utilized for the development of civilizations over the periods. The reservoirs, constructed across the river streams as part of water resources development projects, are the means for storing and using the water for various purposes. Any development poses a challenge in its wake and it is the sedimentation in the case of big projects like Tungabhadra Project which is located in Karnataka, India. The project has a catchment area of 28,519.41 Sq Km, located entirely in Tungabhdra Upper Sub basin. It serves 3.5 Lakh hectares in Karnataka and 1.46 Lakh hectares in undivided Andhra Pradesh. The sedimentation in the project has become alarming as the cost of removing the existing sediment is approximately equal to the cost of constructing another project of the same capacity. The present paper throws specific insights into quantification of sedimentation and its influence on life of the reservoir.

Key Words: Sedimentation Yield, Trap Efficiency, Catchment Area, Watershed & Capacity Survey

Introduction:

The reservoir sedimentation is a natural process which encompasses the production of erosion in the catchment area due to rainfall, its transportation by the run off and ultimate deposition in the reservoir. The sedimentation pattern of Tungabhadra project has been studied by Tungabhadra Board by carrying reservoir surveys from the year of commission of project in 1953 to 2008. The details of the eight surveys are given in Table 1. The actual average rate of siltation is 0.575 TMcft/Year as against the design rate of siltation of 0.431 TMcft/Year. An analysis has been carried out to quantify the sediment yield in terms of weight of the sediment reaching the reservoir per year. The influence of sedimentation on life of reservoir has been studied further.

Table 1: Capacities of Tungabhadra Project from Reservoir Surveys (TMcft)

No	Year of Survey	Dead Storage	Live Storage	Gross Storage	Annual rate of decrease in Storage (Between Successive Surveys)
1	1953	1.159	131.312	132.468	
2	1963	0.249	114.411	114.66	1.7808
3	1972	0.073	121.007	121.08	-0.7133
					(0.5993) *
4	1978	Nil	117.695	117.695	0.5642
5	1981	Nil	115.68	115.68	0.6717
6	1985	Nil	111.832	111.832	0.962
7	1993	Nil	111.5	111.5	0.0415
8	2004	Nil	104.34	104.34	0.651
9	2008	Nil	100.855	100.855	0.871

* Calculated by comparing with gross storage in 1953

Tungabhadra Project:

The Tungabhadra project was constructed at Longitude 76º 20' 10" E and Latitude 15º 15' 19" N, on the river Tungabhadra at Mallapuram village in Hospet Taluk of Bellary District in Karnataka. Tungabhadra has got its name from two tributaries Tunga and Bhadra which join together to form Tungabhadra river. The two tributaries originate from Western Ghats and flow towards east. The catchment area which is located in Tungabhadra Upper sub basin, is delineated and classified into 45 watersheds. The Tungabhadra river travels 382 Km in Karnataka, forms boundary between Kanrnataka and Andhra Pradesh for 58 Km and finally runs for 91 Km in Andhra Pradesh before joining Krishna River. The project comprises of 1040 m long masonry dam, 546.8 m long composite dam and 152.4 m long earth dam. The project is managed and maintained by Tungabhadra Board. The Krishna Water Disputes Tribunal (KWDT) has awarded allocation of 151.49 TMcft to

Karnataka and 78.51 TMcft to Andhra Pradesh, totaling 230 TMcft. The map showing 45 watersheds and Tungabhadra Project is given in Figure 1.

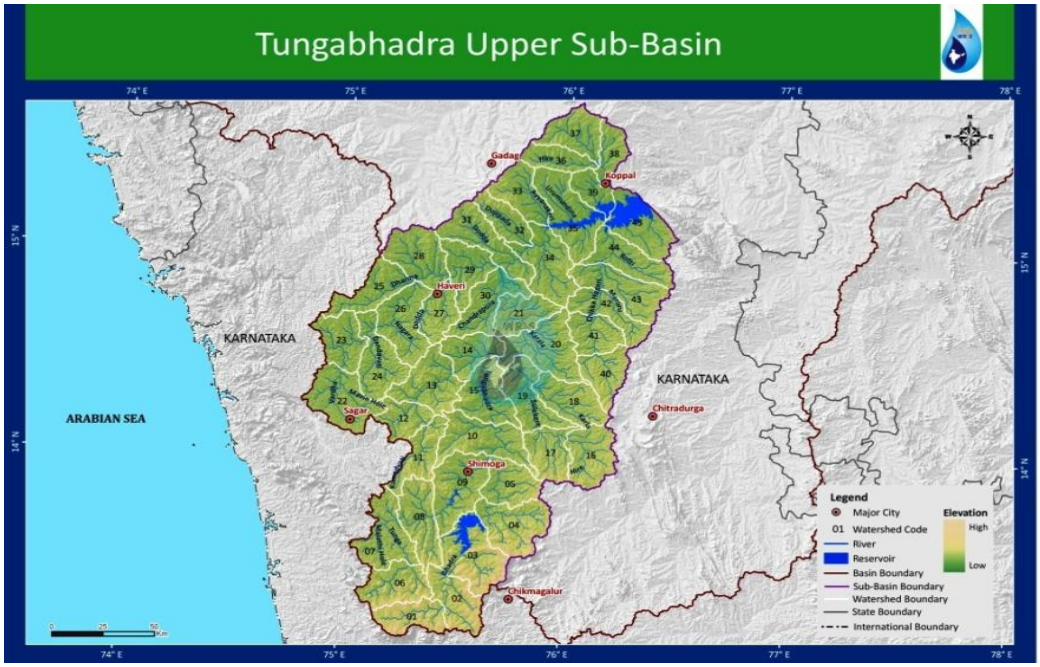

Figure 1: Map showing 45 watersheds in catchment area and Tungabhadra Project

Methodology:

The reservoir surveys are carried out to show the changes in storage volumes between any two surveys. The rate of sedimentation is usually expressed as volume lost per year. The sedimentation yield refers to the total quantity of sediment reaching the reservoir from the catchment, usually in Tons/Sq Km/Year. The relationship between volume and weight of the sediment enables the calculation of the sediment yield. The sediment yield gives an idea of how much sediment is reaching the reservoir if the sediment produced in the entire catchment is known. The trap efficiency is defined as the ratio of sediment trapped in reservoir and the incoming sediment and is calculated using the formula $\gamma = 100\left(1 - \frac{1}{1+100X}\right)^{1.5}$ where X is Capacity Inflow ratio (C/I). The sediment yield is calculated by considering the rate of sedimentation, the relationship between volume and weight and trap efficiency.

Assessment of Sediment Yield:

The specific weight of the sediment of the Tungabhadra Project is measured as 12KN/m^3 and the sediment yield is calculated in the Table 2. The sediment yield is translated into depth of soil cover eroded on the catchment area of the project. It works out to be 0.599 mm/Year.

Table 2: Calculation of Sediment Yield of Tungabhadra Project

Year	Reservoir Capacity (TMCft)	Average Capacity (TMCft) C	Inflow (TMcft) I	X=C/I	Trap Efficiency	Loss of Volume (TMCft/ Year)	Sediment Trapped (Tons/SqKm/ Year)	Sediment Yield (Tons/SqKm/ Year)
1953	132.473							
1954	131.874	132.174	594.467	0.222	0.936	0.599	725.641	775.142
1955	131.275	131.575	483.900	0.272	0.947	0.599	725.641	766.037
1956	130.676	130.976	367.698	0.356	0.959	0.599	725.641	756.411
1957	130.077	130.377	566.50	0.230	0.938	0.599	725.641	773.445
1958	129.478	129.778	432.358	0.300	0.952	0.599	725.641	762.203
1959	128.879	129.179	542.96	0.238	0.940	0.599	725.641	771.868
1960	128.280	128.580	720.822	0.178	0.921	0.599	725.641	787.508
1961	127.681	127.981	415.689	0.308	0.953	0.599	725.641	761.280
1962	127.082	127.382	862.562	0.148	0.906	0.599	725.641	800.580
1963	126.483	126.783	507.237	0.250	0.943	0.599	725.641	769.621
1964	125.884	126.184	321.803	0.392	0.963	0.599	725.641	753.576
1965	125.285	125.585	460.148	0.273	0.947	0.599	725.641	765.885
1966	124.686	124.986	317.715	0.393	0.963	0.599	725.641	753.485
1967	124.087	124.387	236.351	0.526	0.972	0.599	725.641	746.421
1968	123.488	123.788	340.292	0.364	0.960	0.599	725.641	755.767
1969	122.889	123.189	310.675	0.397	0.963	0.599	725.641	753.263
1970	122.290	122.590	401.132	0.306	0.953	0.599	725.641	761.547
1971	121.691	121.991	457.200	0.267	0.946	0.599	725.641	766.814

1972	121.080	121.386	297.130	0.409	0.964	0.611	740.178	767.521
1973	120.516	120.798	238.987	0.505	0.971	0.564	683.241	703.617
1974	119.952	120.234	306.466	0.392	0.963	0.564	683.241	709.529
1975	119.388	119.670	308.075	0.388	0.963	0.564	683.241	709.794
1976	118.824	119.106	487.091	0.245	0.942	0.564	683.241	725.579
1977	118.260	118.542	189.154	0.627	0.977	0.564	683.241	699.659
1978	117.695	117.978	275.408	0.428	0.966	0.565	684.452	708.559
1979	117.020	117.358	558.775	0.210	0.933	0.675	817.708	876.799
1980	116.345	116.683	291.341	0.401	0.964	0.675	817.708	848.525
1981	115.680	116.013	553.100	0.210	0.933	0.665	805.594	863.887
1982	114.718	115.199	362.649	0.318	0.955	0.962	1165.386	1220.847
1983	113.756	114.237	369.482	0.309	0.953	0.962	1165.386	1222.380
1984	112.794	113.275	316.253	0.358	0.960	0.962	1165.386	1214.530
1985	111.832	112.313	303.183	0.370	0.961	0.962	1165.386	1212.892
1986	111.791	111.811	217.267	0.515	0.972	0.041	50.274	51.746
1987	111.749	111.770	244.058	0.458	0.968	0.041	50.274	51.930
1988	111.708	111.728	163.482	0.683	0.978	0.041	50.274	51.381
1989	111.666	111.687	252.433	0.442	0.967	0.041	50.274	51.988
1990	111.625	111.645	224.061	0.498	0.971	0.041	50.274	51.795
1991	111.583	111.604	316.036	0.353	0.959	0.041	50.274	52.424
1992	111.542	111.562	372.075	0.300	0.952	0.041	50.274	52.810
1993	111.500	111.521	521.609	0.214	0.934	0.041	50.274	53.842
1994	110.849	111.175	309.868	0.359	0.960	0.651	788.634	821.835
1995	110.198	110.524	540.598	0.204	0.931	0.651	788.634	847.197
1996	109.547	109.873	180.912	0.607	0.976	0.651	788.634	808.192
1997	108.896	109.222	211.524	0.516	0.972	0.651	788.634	811.655
1998	108.245	108.571	339.815	0.319	0.955	0.651	788.634	825.948
1999	107.594	107.920	323.181	0.334	0.957	0.651	788.634	824.324
2000	106.943	107.269	328.877	0.326	0.956	0.651	788.634	825.179
2001	106.292	106.618	322.176	0.331	0.956	0.651	788.634	824.649
2002	105.641	105.967	160.082	0.662	0.978	0.651	788.634	806.572
2003	104.990	105.316	126.740	0.831	0.982	0.651	788.634	802.913
2004	104.340	104.665	117.100	0.894	0.983	0.650	787.423	800.675
2005	103.469	103.905	171.150	0.607	0.976	0.871	1055.147	1081.324
2006	102.598	103.034	316.790	0.325	0.956	0.871	1055.147	1104.182
2007	101.727	102.163	296.270	0.345	0.958	0.871	1055.147	1101.377
2008	100.855	101.291	476.020	0.213	0.933	0.872	1056.358	1131.692
Average						0.575	696.412	729.102

Influence on Life of Reservoir:

The influence of sediment on life of reservoir is studied by carrying out systemic analysis as shown in the columns of Table 3. The analysis gives an insight into how the actual rate of sedimentation and design rate sedimentation alter the filling periods of sedimentation.

Table 3: The Pattern of Filling of Reservoir with Sediments

Year	Reservor Capacity (TMcft)	Percentage of Reservor Capacity	Reservoir Capacity Lost (TMcft)	Percentage of Capacity Lost	As per design	Actual
1953	132.473	100.000	0.000	0.000	1953	1953
1954	131.874	99.548	0.599	0.452		
1955	131.275	99.096	1.198	0.904		
1956	130.676	98.643	1.797	1.357		
1957	130.077	98.191	2.396	1.809		
1958	129.478	97.739	2.995	2.261		
1959	128.879	97.287	3.594	2.713		
1960	128.280	96.835	4.193	3.165		
1961	127.681	96.383	4.792	3.617		
1962	127.082	95.930	5.391	4.070		
1963	126.483	95.478	5.990	4.522		
1964	125.884	95.026	6.589	4.974		
1965	125.285	94.574	7.188	5.426		
1966	124.686	94.122	7.787	5.878		
1967	124.087	93.670	8.386	6.330		
1968	123.488	93.217	8.985	6.783		
1969	122.889	92.765	9.584	7.235		
1970	122.290	92.313	10.183	7.687		
1971	121.691	91.861	10.782	8.139		
1972	121.080	91.400	11.393	8.600	1976	1972
1973	120.516	90.974	11.957	9.026		
1974	119.952	90.548	12.521	9.452		
1975	119.388	90.123	13.085	9.877		
1976	118.824	89.697	13.649	10.303		
1977	118.260	89.271	14.213	10.729		

1978	117.695	88.845	14.778	11.155	1982	1978
1979	117.020	88.335	15.453	11.665		
1980	116.345	87.825	16.128	12.175		
1981	115.680	87.323	16.793	12.677	1985	1981
1982	114.718	86.597	17.755	13.403		
1983	113.756	85.871	18.717	14.129		
1984	112.794	85.145	19.679	14.855		
1985	111.832	84.419	20.641	15.581	1991	1985
1986	111.791	84.387	20.683	15.613		
1987	111.749	84.356	20.724	15.644		
1988	111.708	84.325	20.766	15.675		
1989	111.666	84.293	20.807	15.707		
1990	111.625	84.262	20.849	15.738		
1991	111.583	84.231	20.890	15.769		
1992	111.542	84.199	20.932	15.801		
1993	111.500	84.168	20.973	15.832	1993	1993
1994	110.849	83.677	21.624	16.323		
1995	110.198	83.185	22.275	16.815		
1996	109.547	82.694	22.926	17.306		
1997	108.896	82.202	23.577	17.798		
1998	108.245	81.711	24.228	18.289		
1999	107.594	81.220	24.879	18.780		
2000	106.943	80.728	25.530	19.272		
2001	106.292	80.237	26.181	19.763		
2002	105.641	79.745	26.832	20.255		
2003	104.990	79.254	27.483	20.746		
2004	104.340	78.763	28.133	21.237	2007	2004
2005	103.469	78.106	29.004	21.894		
2006	102.598	77.448	29.875	22.552		
2007	101.727	76.791	30.746	23.209		
2008	100.855	76.132	31.618	23.868	2013	2008

Results and Discussion:

The following are the results of the research work carried out on sedimentation in Tungabhadra Project.

- ✓ The sediment yield of Tungabhadra Project is 729.102 Tons/Sq Km/Year
- ✓ The average depth of soil cover removed as a result of erosion from the catchment is 0.599 mm per year
- ✓ The sediment got deposited in the reservoir well in advance of time as compared to the timing based on design rate of sedimentation.
- ✓ The sediment production in the catchment area can be calculated if the sediment delivery ratio (SDR) is available for the catchment area. The Tungabhadra Upper sub basin which is the catchment for the project is not yet thoroughly studied to estimate SDR. The extension of this work aims at finding out SDR.

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