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An Assessment of the Siltation and Sediment Generation in Yusmerg Dam Located in Jammu and Kashmir

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Abstract: Although siltation is a natural process, human activity can speed it up and cause serious issues for reservoirs, lowering their usable volume for irrigation. One illustration of this issue was the Yusmerg dam's mirror water area shrinking by 48.3% over the course of 20 years. Thus, the purpose of this study was to assess the siltation and sediment production of the dam using a methodology that may be used for small earth dams used for agriculture. The amount of silt deposited in the reservoir was tracked for this purpose every month of the year. With a retention sediment percentage ranging from 53.9 to 94.5% and a high specific sediment output, the Yusmerg dam will fully silt in a maximum of 57 years. Restoring permanent preservation areas and clearing 17,500 m3 of silt from the dam's riverbed should be done as little as possible.
Keywords: hydro-sedimentology, use and land occupation, erosion.

I. INTRODUCTION

The deposition of sediment carried by water courses is known as siltation, and it occurs when the kinetic energy of the particles falls below what is required to maintain their suspension. The saturation value (CARVALHO, 2008) defines this dynamic and is dependent on the sediment's specific weight, particle size, and flow rate as well as the slope of the water courses. Although this is a natural process, it can worsen owing to poor soil management, which can lead to a decrease in the water's quality and availability (POLETO et al., 2010). Increased soil loss and sediment concentration in water are caused by the shift in land use, with farm and urban perimeters connected to the average slope in the basins (VANZELA et al., 2010; MINGOTI & VETTORAZZI, 2011), exacerbating the siltation process. This happens because a decrease in the soil's infiltration rate causes surface runoff to increase (GOMES et al., 2007), which in turn increases the water's kinetic energy and maximizes its ability to carry sediment.

OLIVEIRA et al. (2011) state that the destruction of the vegetation along riverbanks has major effects on the ecosystem, including siltation, pollution, and contamination from agricultural goods. WU et al. (2012) obtained effects similar to these, quantifying the anthropogenic and climatic impacts on sediment production. It was noted that in the 1980s, deforestation caused the sediment load of the Pearl River (Zhujiang), China, to increase by nearly 20%, even with the construction of dams.

The principal effects of anthropogenic soil use on the watershed include those that have to do with busbars' decreasing usable lives. These hydraulic constructions are man-made works of art that change the flow regime and make them more prone to silting. The widening of the cross section, which lowers the flow velocity of water, provides an ideal environment for the deposition of solid materials carried by the water channel or arising from runoff from the watershed (ALBERTIN et al., 2010; SANTOS & HERNANDEZ 2013). However, this characteristic is what causes the sediment load in rivers with dams to significantly decrease (SYVITSKI & KETTNNER, 2011). Rainfall patterns and the short-term temporal fluctuation of sediment generation in watersheds are connected. The reservoirs, also known as dikes, are crucial for regional development and water resource management because, in the current context, they are primarily used for irrigation, drought control, hydroelectricity, and urban water supply (UNITED NATIONS ENVIRONMENTAL PROGRAMME, 2007). Consequently, the decreased water supply brought on by silting in the reservoirs may have detrimental effects on regional growth, particularly in cities that rely on these systems for agriculture.

II. STUDY AREA

Yusmarg or Yousmarg (meaning 'Meadow of Jesus') is a hill station in the western part of the Budgam district of Jammu and Kashmir, India. It is situated 53 km (33 mi) south of Srinagar, the summer capital of the state. It lies at an altitude of 2,396 m (7,861 ft.) above sea level. It lies between the geographical coordinates of 33.8316° N, 74.6644° E. It is located in the Pir Panjal peaks, a sub range of Himalaya. Yusmarg of district Budgam experiences temperate climate, where summers are mild while winters are extremely cold and chilly.

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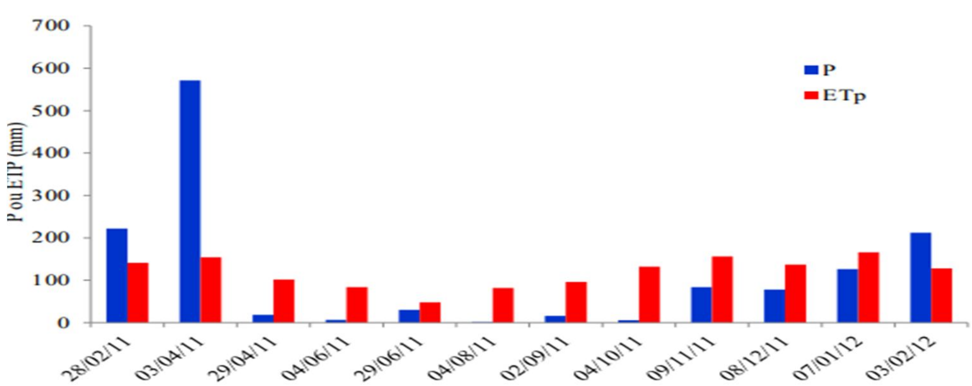
Between February 2011 and February 2012, when the study was carried out, there were 1,373 mm of total rainfall and 1,426 mm of total potential evapotranspiration (INTEGRATED CENTER OF AGRO METEOROLOGICAL INFORMATION, 2012).



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III. METHODOLOGY

Equation 1 served as the foundation for the dam's siltation analysis (CARVALHO et al., 2000).

$$T = \frac{V_{res}}{365 \cdot S}$$

where, T = Time to siltation (years);
Vres = Total volume of the dam (m3), and
S = Volume of sediment in the dam (m3 d $^{-1}$).
Using a bathymetric survey method (vau) with a PVC pipe graduated 5 by 5 cm for the collection of depths and one station, based on two GPS control points planted near the dam, the entire volume of the dam was measured in April 2012. Depths were introduced in the planimetric data using spreadsheet software, and data were downloaded into DataGeosis Office software. The area of the water's surface and the total volume of the dam were then determined using the digital terrain model (DTM), which was created from an uneven grid of 33 depth points. The results were 18,548 m2 and 18,598 m3, respectively.

The calculation of the volume of sediment in the dam (S) was performed using following equation

$$S = \frac{S'}{d}$$

Where,
S - Volume of sediment withheld in the dam (m3 d -1);
S' - mass of sediment withheld in the dam (kg d-1), and
ds - Density of solid sediments on the bottom of the dam (kg m-3)
Using the same tube that was used to measure the depths of the dam, five samples weighing roughly 25 g each were taken in order to calculate the density of solid sediments on the bottom of the dam (ds) during the bathymetry.
After that, the samples were taken to the laboratory for analysis and put in plastic containers. Following the results were obtained, the average density of solids for all samples collected—1.89 g cm-3 (1,890 kg m-3—was taken into consideration.

The mass of sediment retained on the dam (S') was determined with the aid of the equation

$$S' = DST_e - DST_s$$

Where:
S' - Mass of sediment retained in the dam (kg d-1);
DSTe - Total sediment discharge entering the dam (kg d-1), and
DSTs - Total sediment discharge coming out of the dam (kg)
The aggregate of the solid discharge at points A, B, and C and the total solid discharge measured at the discharger's (concrete tube) exit at point D was the total solid discharge that entered the reservoir.
The total solid discharge from each point A, B and C was determined by the following equation
DST=DSS +DSL
where, DST = Total solid discharge (kg d-1);
DSS = Suspended solid discharge (kg d-1), and
DSL = Riverbed Solid discharge (kg d-1).
Because the discharger from upstream to downstream of the dam is above the bottom of it, the total solid discharge (DST) exiting the dam (point D) was solely calculated by the suspended solid discharge (DSS).
The suspended solid discharges, of input or output of the dam, were determined according to the equation

$$DSS = (C_{ST} \cdot Q) \cdot 0{,}024$$

Where, DSS = Suspended solid discharge (kg d-1);
CST = Total solids (mg L-1), and

Q = Stream flow (m3 h -1).

The integrating float approach was utilized to ascertain the stream flow. Water samples were sampled at sites A, B, C, and D, and their concentrations of total solids were determined using gravimetric analysis. The water analysis were performed in the laboratory.

Using the COLBY (1954) and (CARVALHO, 2008) method, the solid discharge of the riverbed was calculated using the equation.

$$DSL = \left(39 \cdot v_m^{3.36} \cdot L \cdot K\right) \cdot 10^3$$

Where, DSL = Solid discharge on the riverbed (kg d-1); v
m = Mean flow velocity (m s-1);
L = Linear width of the channel section (m), and
K = Correction factor.

At the time of the flow measurements, the average flow velocity and the channel's linear section width were determined. Using the following equation, the correction factor was calculated based on the relative and total solids concentrations:

$$K = 1.18 \cdot \left(\frac{C_{ST}}{C_R}\right)^{0.5}$$

Where, K = Correction factor;
CST = total solids concentration (mg L-1), and
CR = Relative concentration (mg L-1) determined by Colby diagram.

All variables' correlation coefficients (r) were calculated using the precipitation total for the seven days leading up to the measurements (P7d), and their variability was plotted against time. The Hopkins (2000) classification scheme for the correlation coefficient (r) was used.

Relationships are categorized based on the correlation coefficient (r).

Correlation coefficient	Correlation
$0.0 \leq r < 0.1$ or $-0.1 < r \leq 0.0$	Very low
$0.1 \leq r < 0.3$ or $-0.3 < r \leq -0.1$	Low
$0.3 \leq r < 0.5$ or $-0.5 < r \leq -0.3$	Moderate
$0.5 \leq r < 0.7$ or $-0.7 < r \leq -0.5$	High
$0.7 \leq r < 0.9$ or $-0.9 < r \leq -0.7$	Very High
$0.9 \leq r < 1.0$ or $-1.0 < r \leq -0.9$	Extremely high

A statistical analysis was conducted to compare the averages of the total solids concentrations, stream flow, and total solid discharges at the dam's entry and departure, divided between the rainy and dry seasons. The GRAVETTER & WALLNAU (1995) criterion was applied in this case, which states that differentiation takes place when the upper and lower bounds of the standard errors of the means do not overlap.

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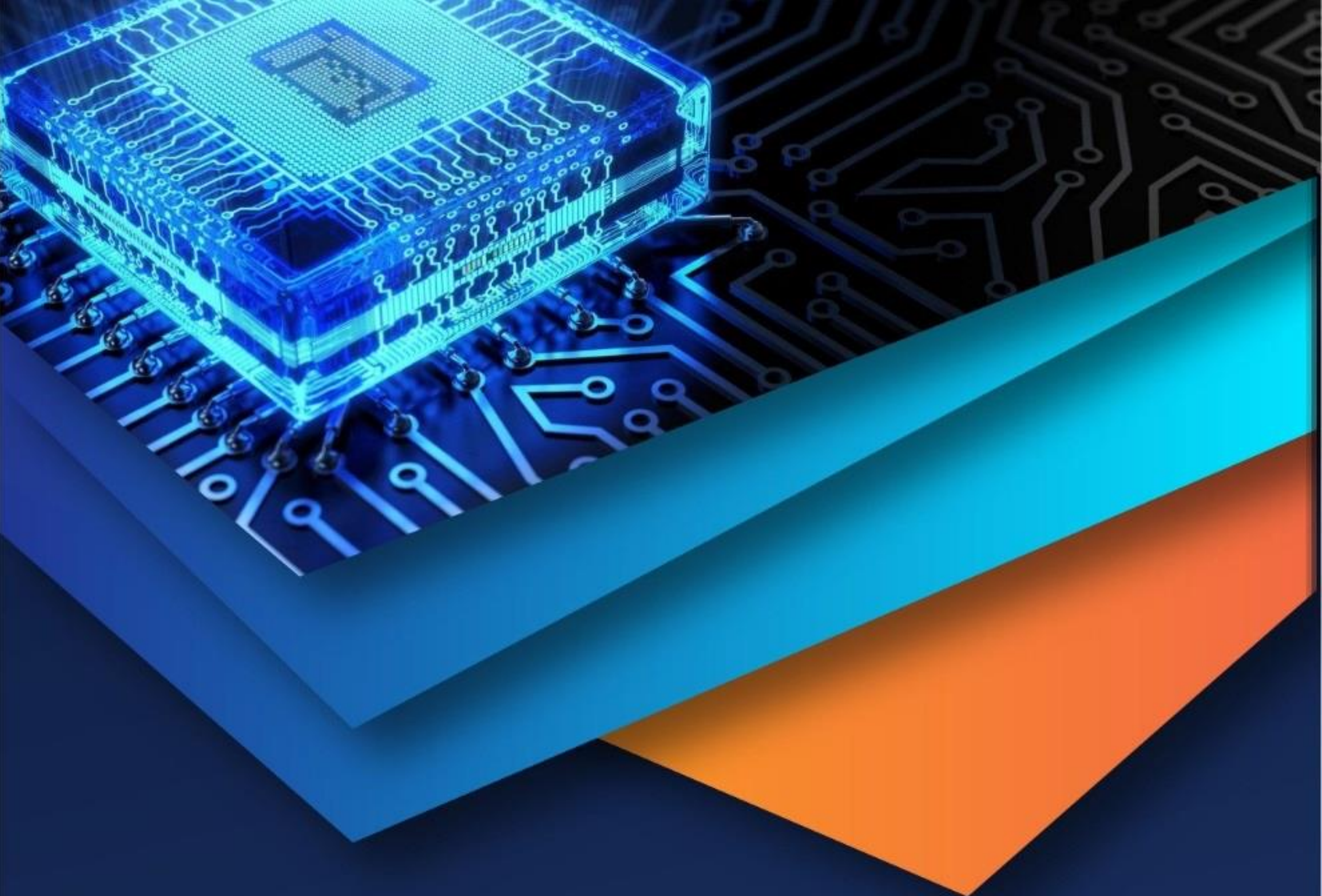

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