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Erosion and Dam Siltation in an Arzangarzan Earthen Dam in Budgam District of Jammu and Kashmir

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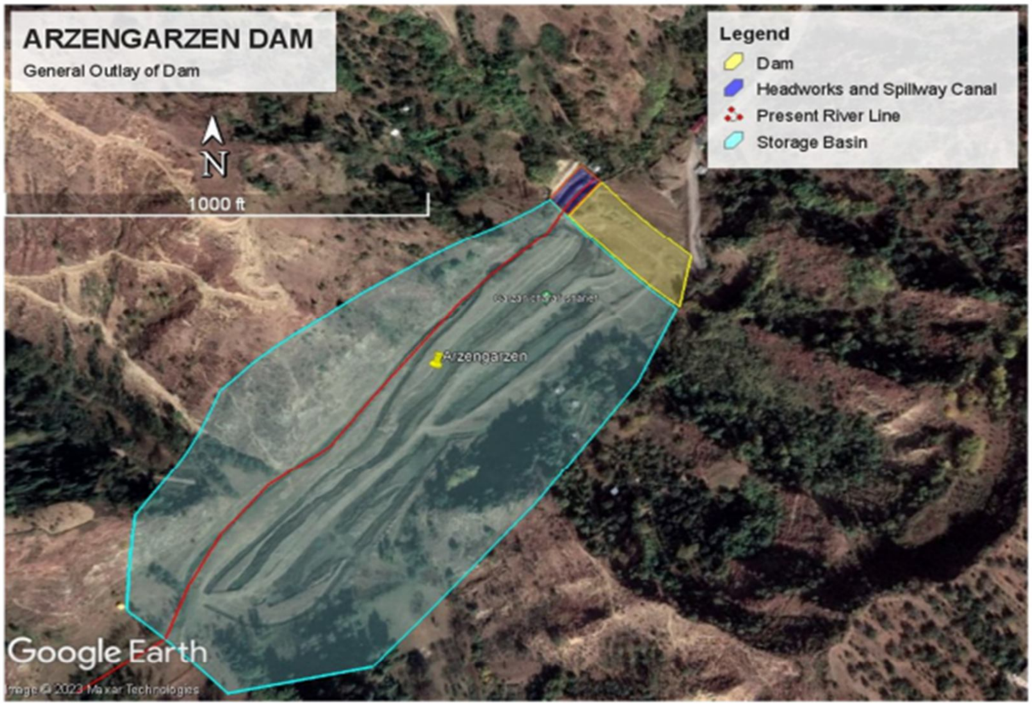
Abstract: Many check dams were built in the Budgam district of Jammu and Kashmir during the 1970s, however after a few years, their entire infill was caused by significant siltation rates. This effort aimed to evaluate the mechanisms producing soil particles and their accumulation in the Arzangarzan dam. To measure the amount of sediments and the overall rate of erosion, a bathymetric survey was conducted.
Fallout 137Cs was also shown to be useful in estimating soil loss in particular regions and determining the primary sources of silt. Different sediment sources were identified thanks to the radiotracer; erosion rates seem to be influenced by topography, vegetation cover, and/or land use.
The contribution of rill and bank erosion could be estimated using the two methodologies, and it seemed to account for roughly one-third of the total deposited sediments.
Combining these methods proved to be an effective way to create watershed sediment budgets in order to support improved soil and water management techniques.
Keywords: bathymetry; caesium-137; erosion; Arzangarzan dam

I. INTRODUCTION

Erosion hastens ecosystem degradation, putting the Budgam district of Jammu and Kashmir in danger of becoming a unfertile. Intense rainfall events in this tiny area provide substantial sediment loads to catchments downstream due to highly erodible soils and sparsely vegetated slopes. Sediment movement and buildup significantly deteriorate water quality and harm water-related infrastructure like reservoirs and canals.
Devastating floods also permanently endanger the populace by destroying roads and bridges. Regretfully, complete siltation of the dams happened quite quickly once it began to operate, usually within five or six years. These failures were caused, in part, by (a) the check dams' inappropriate sites; (b) their initial modest volume in comparison to the catchment area; and (c) inaccurate calculations of siltation rates derived from empirical equations.
The Arzangarzen dam in the Budgam district of Jammu and Kashmir got filled completely with sediment in less than seven years. A check dam located in the near byi watershed was chosen as a case study to evaluate the processes of erosion and sedimentation in the region.
The sediments that were deposited were the result of various erosive processes, including bank, gully, and rill erosion as well as overland flow. The examination of certain sediment erosion and dam siltation characteristics in Arzengarzen dam may yield important insights into the distinct degradation processes that take place in the catchments while the dam is in operation (Foster & Walling 1994; Navas et al., 1998).
This study aimed to determine the erosion rates causing the Arzangarzan dam to silt and to identify the primary sediment delivery processes using a variety of approaches. To determine the amount of sediment that had accumulated in the check dam, A bathymetric survey was conducted.
The 137Cs radiometric method was used in a few representative catchment areas to identify the sediments' source areas and categorize them based on varying levels of erosion. The proportional contributions of the several erosive processes that resulted in the siltation of the Arzangarzen dam were established with the aid of both approaches used in tandem.

II. STUDY AREA



Location of the sediment profiles surveyed in the Arzengarzen dam

III. METHODOLOGY

A bathymetric survey was used to estimate the total volume of sediment that accumulated in the Arzengarzen dam. Using an electronic theodolite and GPS, the bottom topography of the reservoir behind the silted-up check dam was measured. A GIS file contained both the most recent topographic map and the one created before the check dam was built. To estimate the volume of sediment in the silted section, the contour lines were converted into a digital elevation map (DEM) of the watershed (Fig. below). A number of samples were used to determine the bulk density of the accumulated material in order to determine the sediment's overall weight. As a result, an average rate of erosion for the entire Arzengarzen watershed can be determined for the years 1973, when the check dam was constructed, and 1979, when it was completely silted in.

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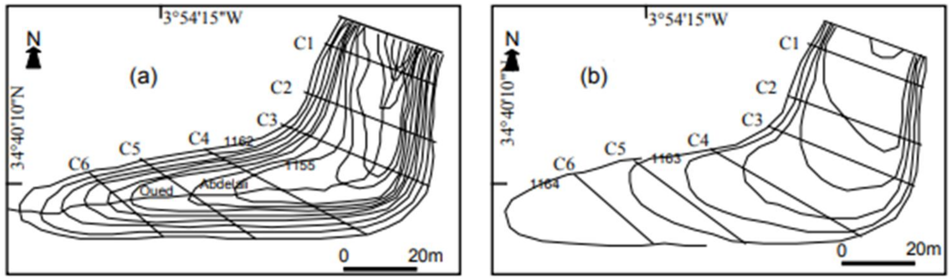


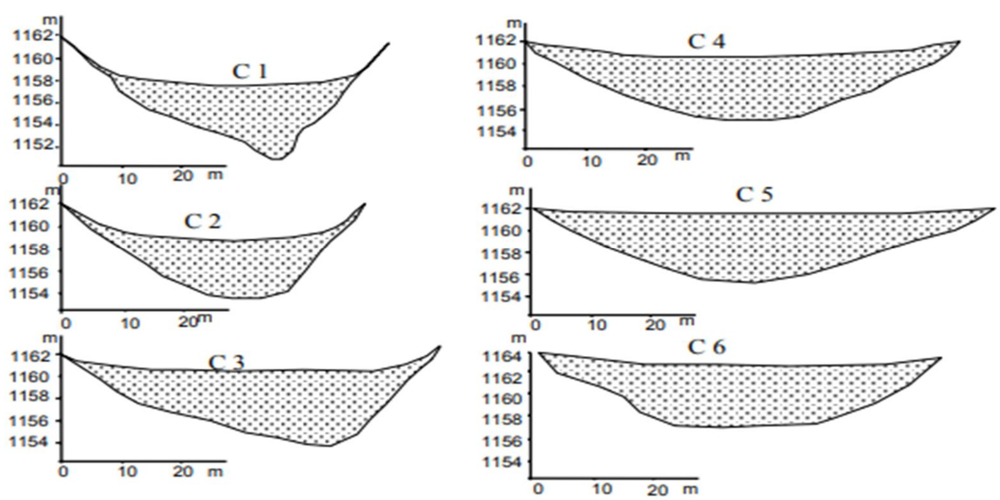
Cx, situation of the transects.

The many sediment sources that led to the check dam's siltation were identified with the aid of the 137Cs method. Several investigations, including those by Richie et al. (1974), Walling et al. (1986), Martz & de Jong (1987), and Loughran et al. (1990), have effectively used this radiotracer in a variety of global contexts. Research conducted in semiarid locations by Bouhlassa et al. (2000), Quine et al. (1994), and Navas & Walling (1992) confirms its potential utility in detecting sources of erosion and sedimentation. A soil survey was conducted to determine the primary morphoedaphic units in order to get estimates of the relative contributions from the various sediment sources in the watershed. Thus, a soil sample plan intended to yield representative findings was established, taking into account land uses and soil types on various lithologies and slope gradients.

A 8-cm drill core was used to gather samples up to a 55-cm depth. After the dry samples were sieved, gamma spectrometry was used to analyze the <2 mm fraction for 149Cs. By comparing the measured 149Cs at the various sample sites with the area's reference inventory, which is 380 mBq cm-2, soil redistribution was evaluated (Faleh et al., 2004). The literature (Mitchell et al., 1980; De Jong et al., 1983; Frederick & Perrens, 1988; Walling & Quine, 1990; Walling & He, 1999) had a number of models that might be used to calibrate the 149Cs data. The Walling & Quine (1990) model for uncultivated soils and the proportionate model for cultivated soils were used to estimate the rates of erosion.

IV. RESULTS

Sediment started to accumulate quickly after the Arzengarzen dam was built in 1973, and it eventually silted completely. 58 000 m3 was the estimated volume of sediment based on the bathymetric survey. About 67 000 t of sediment have been deposited overall in the check dam (Table 1, Fig. 4). A variety of processes, including bank, gully, and rill erosion, as well as overland flow, contributed to the sediment that filled the dam. The bathymetric survey's interpretation revealed an average erosion rate of about 40 t ha-1 year-1 for the entire watershed. This rate does not account for suspended sediment that is exported out of the catchment during floods or sediment that is deposited within the catchment. Furthermore, because the watershed is ungauged and lacks a rain gauge, this average rate does not account for fluctuations in the siltation rate caused by variations in precipitation and discharge. As a result, it was unable to link the fluctuations in the infilling rate to the Arzangarzan dams sources hydrological cycle. In spite of these restrictions. It is believed that the catchment's average erosion rate will remain constant at this level.



Cross-section profiles of the Arzangarzan dam impoundement

The 137Cs approach was used to determine the source areas of the sediment and to evaluate the relative contribution of overland flow to the infilling process, taking into account the diversity of soils, geomorphic components, land use, and vegetation cover.
After estimating the rates of erosion and aggradation for the years 1963 to 2001 (the year of the soil survey), a classification of the source areas supplying sediment was developed (Table 2). The majority of the sediment appears to come from the regions that correspond to sample sites A1, A3, A5, and A11. The erosion rates range from 24 to 42 t ha-1 year-1, and the soils have nearly completely lost their surface horizons. The regions that correspond to sampling sites A2, A4, A7, and A10 show signs of partial surface horizon loss. Additionally, these areas contribute less to the sediment load since their erosion rates are lower, ranging from 4 to 16 t ha-1 year-1.

A. *Classification of sediment sources according to erosion rates in the Arzangarzen Dam*

Source of sediment	size	land use	slope%	*I* (mBqcm^3)	E/A(t ha^{-1} year^{-1}
Main	A*II*	Cereal Crops	25	91.2	44.8
Erosion Index	A 5	Matorral light	38	90.3	36.2
	A3	Matorral light	21	126.7	33.6
	A *I*	Matorral dense	44	154.2	27.5
Secondary	A4	Cereal crop	8	185.3	16.3
Erosion middle low	A7	Matorral light	16	192. 2	14.6
	A2	Matorral dense	20	201.2	16.2
	A10	Matorral light	9	253.2	22.0
Reference sight	A12		7	345.7	74.1
Aggradation	A 14	Matorral light	10	321.5	196.8
	R	Dam	-----	393.4	269.0

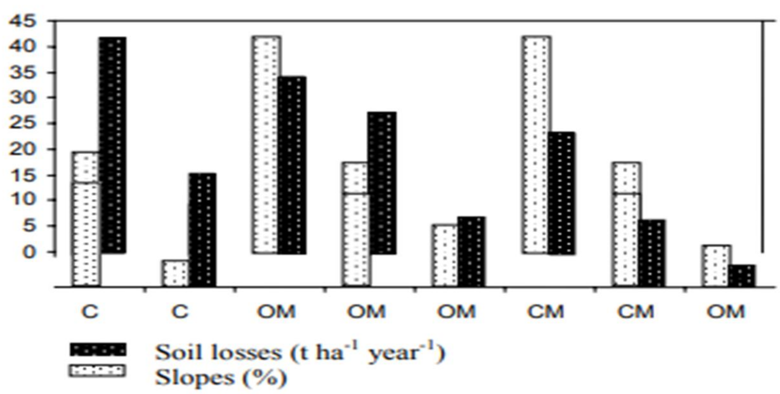
I : inventories, E: erosion , A: aggradation

B. *Erosion and Dam siltation in Arzangarzan dam*

Grain size and erodibility for various lithologies in the Arzangarzan dam

Parent materials	*OM* (%)	Clay (%)	Silt+fine sand (%)	Sand (%)	Gravels (%)	Structure code	Permeability code	*K*
Clays	3.1	7.2	60.4	12.0	13.4	3	5	0.38
Marls-limestones	2.2	10.3	53.9	32.1	3.9	3	3	0.35
Marls	1.5	7.9	57.2	15.8	18.3	3	4	0.37

OM: organic matter; *K*: erodibility.



Erosion rates based on slopes and land use of Arzangarzan dam

There is no obvious correlation between lithology and the measured soil losses. The comparable eroding potentials of the materials and their relative homogeneity could be the cause.

The majority of the sediment is supplied by the cereal-growing soils on steeper slopes compared to the cultivated soils on lower slopes. The regions of open "matorral," or bushy Mediterranean-type vegetation made up of different shrubs, exhibit varying contributions to the sediment load; steep slopes have the highest rates of erosion while less steep slopes have significantly lower rates. More thick plant cover, like that found in a close-growing "matorral," tends to shield the soil surface from erosion, which lowers erosion rates for slopes that are of the same gradiant. Thus, it seems that the terrain and vegetative cover are the main elements regulating erosion in the watershed. Therefore, it would seem that slope gradient and land use are the primary factors influencing the distribution and significance of the sediment source areas.

V. CONCLUSIONS

Utilizing bathymetric surveys in conjunction with radiometric techniques has shown to be an effective approach for researching sedimentary processes and erosion at the watershed scale. With the use of this combined method, it was possible to quantify overall erosion, pinpoint the sources of sediment, and calculate the relative contributions of the various erosion processes and sediment sources within the watershed. An evaluation of the relative contributions of physiography, vegetation cover, and land use to the rate of soil erosion was also made possible by the combined method.

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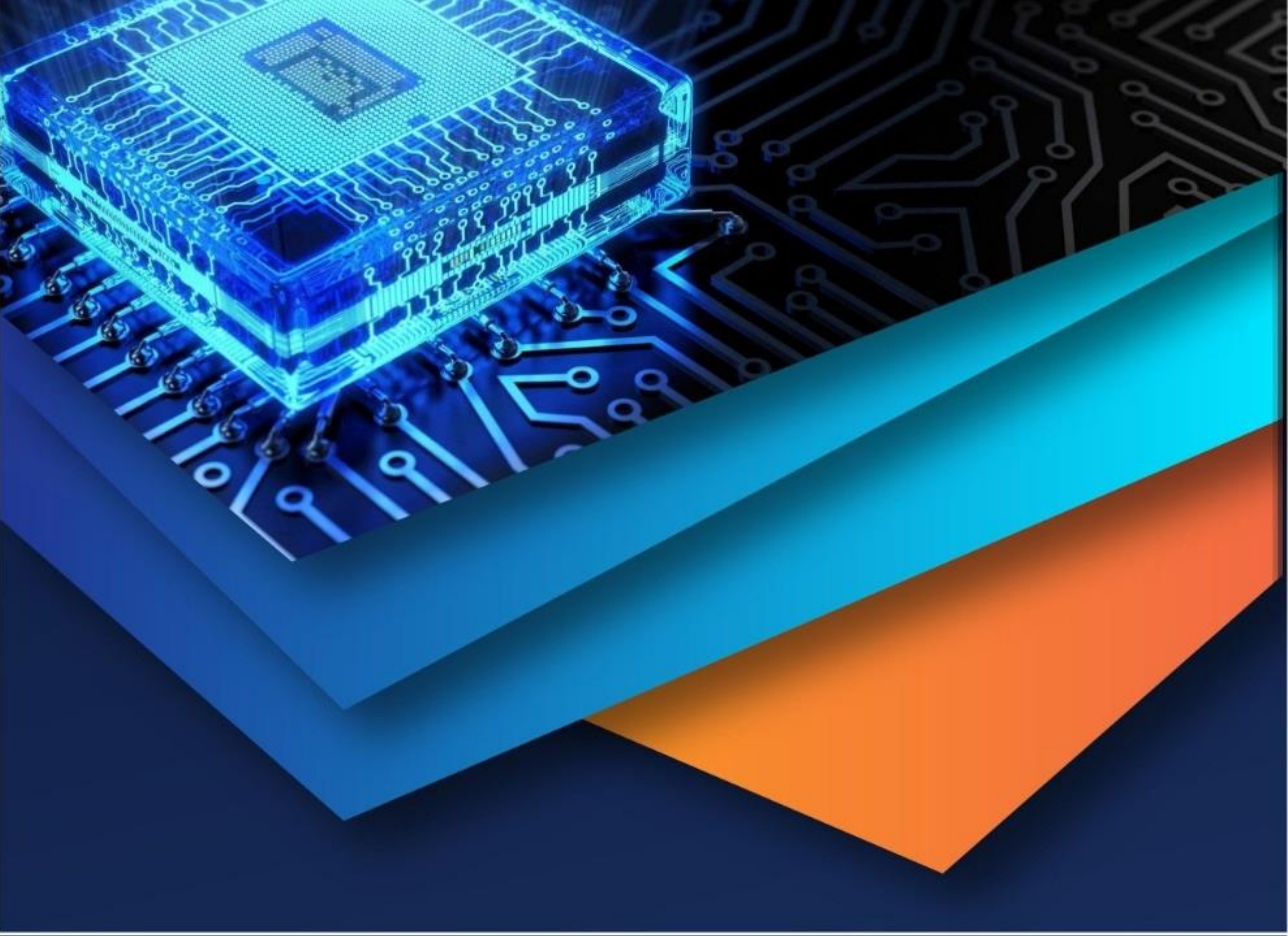

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