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Calculating the suspended sediment load of the Dez River

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ABSTRACT The suspended sediment discharge of the Dez River at the Talezang gauging station has been calculated using a variety of suspended sediment discharge/flow relationships. The results obtained have been evaluated by comparison with estimates of sediment load based on surveys of the downstream reservoir. This evaluation demonstrates that the rating relationship based on all available samples produces the most reliable results.

INTRODUCTION

Supended sediment loads are frequently calculated using suspended sediment discharge/flow rating relationships. In this case a rating relationship is established by direct sampling and this is subsequently applied to the continuous record of water discharge to estimate the sediment load. As the period of measurement increases in length, both the number of samples available and the length of the discharge record increases and it is necessary to decide how to establish the best rating relationships. It is, for example, possible to derive rating relationships for individual years or for each month, or to use a single rating relationship for the entire period of record. In order to investigate this problem further, a case study has been undertaken using data collected from the Talezang gauging station on the Dez River. This station was selected because it is located upstream of the Dez dam and the estimates of suspended sediment load obtained using rating curves can be compared with the results of reservoir sediment surveys, in order to assess their reliability.

CHARACTERISTICS OF THE DEZ BASIN

The Dez River rises in the Zagross Range and joins the Karun River at Bamdej. The catchment area of the Dez River at its confluence with the Karun is estimated to be 21720 km^2. The maximum altitude of the basin is 4124 m and the minimum (at Bamdej) is 19 m. The Dez dam, which is located to the north-west of Ahvaz city, was brought into operation in 1962. The catchment area of the Dez River above the dam site is 17372 km^2. The associated reservoir is about 60 km in length. The Talezang gauging station, which has provided the data used in this study, is located 10 km upstream of the reservoir inlet. The catchment area above the Talezang gauging station and the ungauged area draining to the reservoir are estimated to be 16132 and 1196 km^2 respectively. Over a period of 32 years, the average discharge of the Dez River at the Talezhang station has been estimated to be 245 $m^2 s^{-1}$. Figure 1 shows the general location of the river basin and the dam.

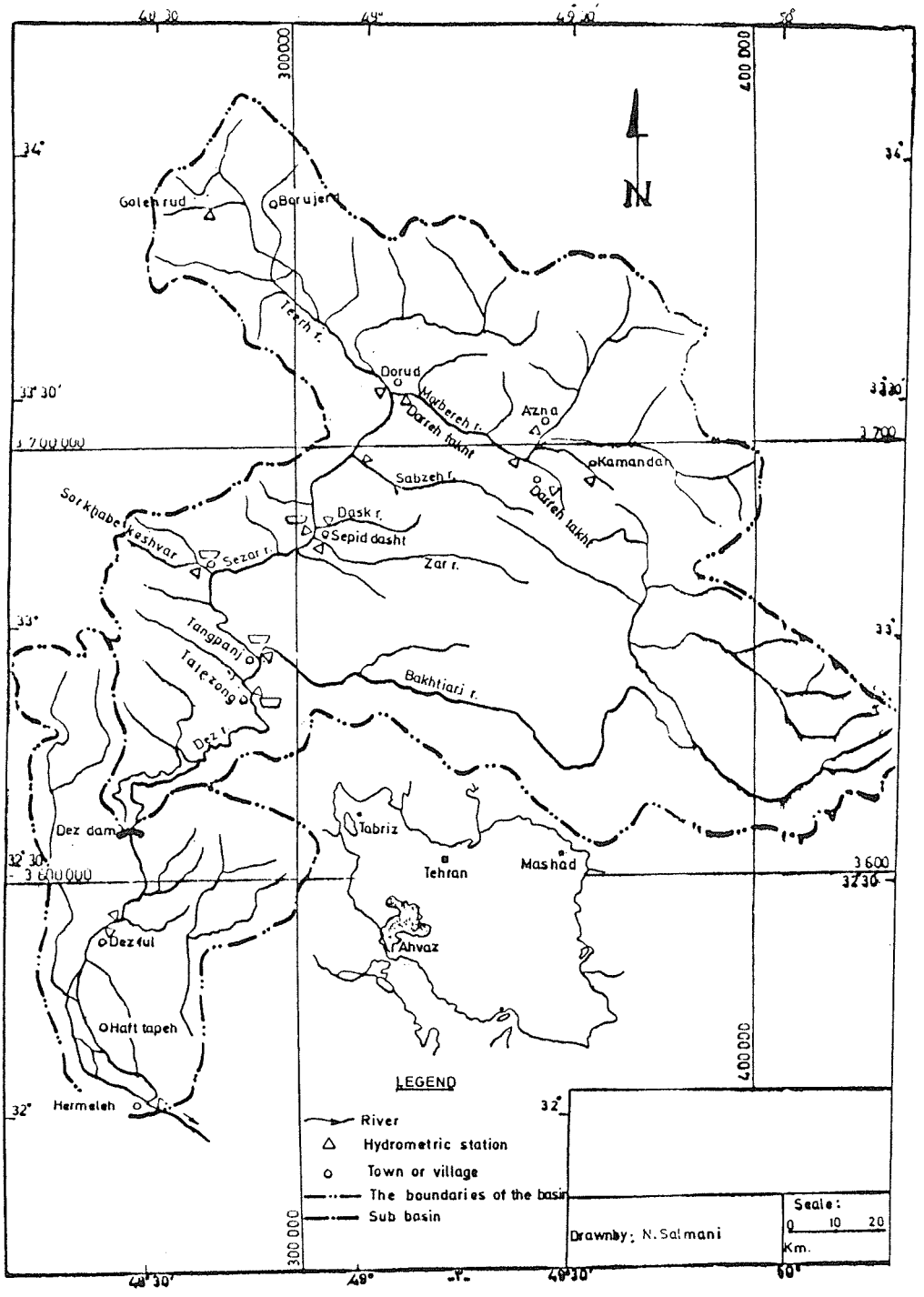

FIG. 1 The Dez River Basin.

THE DATA USED IN THE STUDY

The data used in this study can be classified as follows:

(a) Suspended sediment concentration data: The data relating to all suspended sediment samples collected at the Talezang gauging station were collated and after quality control 236 samples with their corresponding discharge values were selected. The number of available for individual years ranged between a maximum of 26 and a minimum of six.

(b) Discharge data: Daily discharge data were available for a period of 33 years (1954-1987).

(c) Reservoir sedimentation surveys: The first reservoir sedimentation survey, which was undertaken at the end of the first decade of operation, provided an estimate of annual sedimentation of 17.5 million tonnes. The second sedimentation survey, which was undertaken at the end of the second decade of operation (1962 - 1983), provided an estimate of annual sedimentation of 9.5 million tonnes.

THE APPROACH

The analysis undertaken involved the following stages.

(a) The calculation of suspended sediment discharge/flow relationships of the following types:
- A single relationship based on all available samples collected during the period 1972-1987 (Fig. 2).
- Annual relationships based on the samples collected during each water year (15 relationships).
- Monthly relationships based on all of the samples taken in different months during the period of record (12 relationships).
- Relationships for separate 5-year periods (3 relationships).

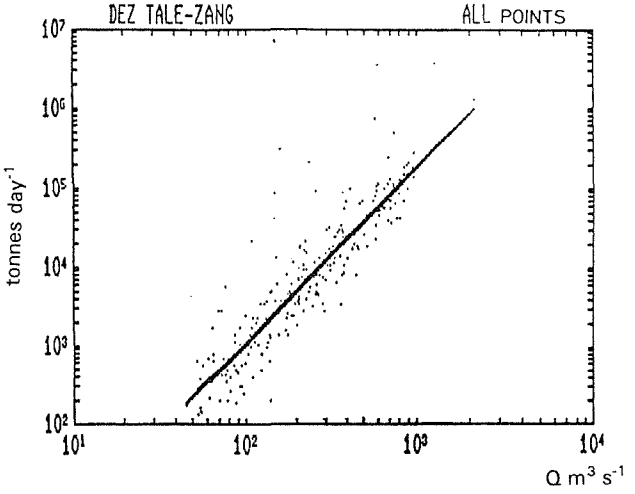

FIG. 2 The suspended sediment discharge / flow relationship based on all the samples

- Relationships for dry and wet periods (2 relationships). This analysis produced 33 separate relationships. In order to facilitate comparison with the reservoir survey data, the sediment rating relationships were used to estimate sediment loads for three separate periods as follows:
- 1962-1987 (25 years), which represents both the period for which daily discharge data are available for the Talezang gauging station after the construction of the dam and the period between the beginning of reservoir operation and the most recent reservoir survey.
- 1972-1987 (15 years), which represents the period of sediment sampling used to establish the rating relationships.
- 1962-1972 (10 years), which represents the period covered by the first reservoir sediment survey.

(b) The annual suspended sediment discharges at Talezang for the above periods were determined using both flow duration curve (FDC) data and direct calculation of daily sediment loads using daily flow (DQ) data. The results are presented in Fig. 3.

RESULTS

The primary purpose of the study reported was to compare the estimates of suspended sediment load obtained using the rating relationships with the equivalent results provided by the reservoir sedimentation surveys, in order to identify the optimum rating relationship estimation procedure. The results provided by the reservoir surveys inevitably involve a degree of error, but they are judged to be sufficiently reliable for the purposes of this study and thus provide an independent source of sediment load data.

Period	Duration (years)	Calculation Procedure and Rating Relationships									
		FDC and all the points	DQ and all the points	FDC and dry and wet periods	DQ and dry and wet periods	FDC and five-year -periods	DQ and five-year -periods	FDC and monthly points	DQ and monthly points	FDC and the year by year curves	DQ and the year by year curves
1962-1987	25	8.4	8.5	8.6	8.3	-	-	10.8	10.0		
		Average 8.45				Average 10.4					
		Ratio = 1.23									
1972-1987	15	9.5	9.7	9.6	9.4	9.4	9.3	13.3	12.1	14.7	13.5
		Average 9.48						Average 12.7			
		Ratio = 1.34									
1962-1972	10	7.2	7.3	7.2	-	-	9.6	8.7			
		Average 7.25				Average 9.15					
		Ratio = 1.28									

FIG. 3 The mean annual suspended sediment load ($t \cdot 10^6$) of the Dez River estimated using different rating relationships and calculation procedures.

The first survey

The reservoir survey indicated a mean annual rate of sedimentation during the first decade (1962-1972) of operation of 17.46 million m^3. This value was converted to a mass using measurements of sediment density. The specific weight of sediments above the water level was between 1880 and 2030 kg m^{-3} and for submerged sediments between 640 and 1080 kg m^{-3}. By considering the discharge regime of the Dez River and the reservoir operating rules, it is clear that most of the sediments are permanently submerged. A value of 900 kg m^{-3} has been taken as the average specific weight over the 10-year period. The annual rate of sedimentation is therefore equal to 15.7 million tonnes.

In order to convert this estimate of reservoir sedimentation to an estimate of the sediment load passing the Talezang gauging station, it is necessary to subtract the sediment input from the catchment area draining directly to the reservoir and from the portion of the basin located between the gauging station and the head of the reservoir. The following equation has been used to derive the correction factor:

$$K = \frac{A1}{A1 + A2 + A3} = 0.93 \quad (1)$$

Where: A1 is the catchment area above the Talezang station, A2 is the intermediate catchment area, and A3 is the area draining directly to the reservoir. By applying this correction factor, the mean annual sediment load of the Dez River at Talezang will be equal to 14.6 million tonnes. This represents the total sediment load and, in order to permit direct comparison with the estimates of suspended sediment load obtained using the rating relationships, it is necessary to subtract the bed load component. There are no direct measurements of bed load, but the limited existing information relating to the grain size distribution of the reservoir deposits and the hydrological regime of the river indicate that bed load represents about 15% of the total sediment load. The mean annual suspended sediment load passing Talezang can thus be estimated at 12.4 million tonnes.

The second survey

The results of this survey indicate that the total volume of sediment deposited in the reservoir during the 21-year period ending in 1983 was 199 million m^3. This value differs substantially from the equivalent value derived from the first survey. However, the results of the second survey have been assumed to be correct and they have been processed in the same way as for the first survey. A specific weight of 1000 kg m^{-3} rather than 900 kg m^{-3} has, however, been assumed. The results are as follows:

- The mean annual sedimentation rate in the reservoir is 9.3 million tonnes.
- The mean annual total sediment load passing Talezang is 8.4 million tonnes.
- The annual suspended sediment load passing Talezang is 7.5 million tonnes.

To assist comparison, the results of the sediment rating curve calculations and the estimates of suspended sediment load based on the reservoir surveys are presented in Fig. 4.

COMPARISON OF RESULTS AND RECOMMENDATIONS

By comparing the estimates of mean annual suspended sediment load presented in Fig. 3, the following conclusions may be drawn:

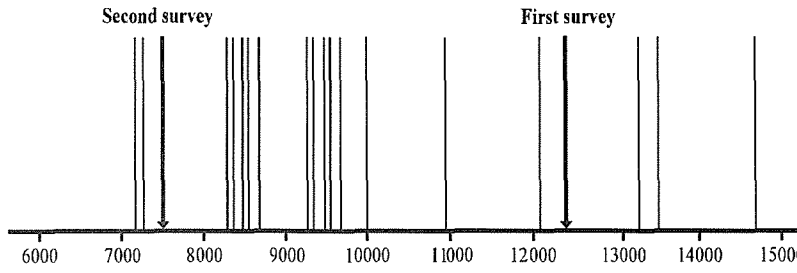

FIG. 4 A comparison of estimates of the suspended sediment load passing Talezang (10^3 tonnes) based on rating relationships and reservoir surveys.

(a) The results obtained using flow duration curve data and the continuous series of daily discharge data are similar.
(b) The results obtained using the rating relationships developed for all the data, for dry and wet periods and for separate five year periods are essentially similar.
(c) The results obtained using the rating relationships for individual months are between 1.23 and 1.34 and on average 1.28 times higher than the loads calculated using the rating relationship based on all the points.
(d) The loads estimated using the rating relationships established for individual years are higher than those estimated using the other rating relationships.
(e) The rating relationships referred to in (b) produce similar results for periods of 25, 15 and 10 years. Differences between the periods reflect variations in discharge between the periods (cf. Table 1).
(f) The load estimate based on the second reservoir survey (7.5 million tonnes) agrees quite closely with the estimates obtained using the rating curves referred to in (b) above (8.4 million tonnes). The second survey would therefore appear to be more accurate. Differences between the survey result and the rating curve load estimates may reflect errors in the assumed bed load proportion and in other aspects of the survey procedure.

TABLE 1 Comparison between the discharge and suspended sediment loads for individual periods.

Period (years)	Sediment load ratio	Discharge ratio
15 : 25	1.12	1.1
15 : 10	1.3	1.25
25 : 10	1.16	1.13

Based on the results obtained in this study, the use of rating relationships developed using all available samples is recommended. Since new data are being continually gathered, rating relationships and load estimates should be updated every 5 years.