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Sediment yield in the Daryacheh-Namak drainage basin, Iran, and its relation to land-use changes

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Abstract Monthly and annual variations in sediment yield during a 24-year period were analysed for 10 sub-catchments in the Daryacheh-Namak drainage basin, Iran. Highest specific suspended sediment yields were recorded at Razin and the lowest at Solan, reflecting large land-use changes in the former, and the presence of relatively resistant formations in the latter sub-catchment. Highest sediment yields were observed in the months of April, March, May and November, and the lowest in September and August. At almost all stations, the highest sediment yield occurs in the spring, reflecting higher rainfall in that season.

Key words Daryacheh-Namak drainage basin; monthly and annual variation; sediment yield

INTRODUCTION

Sediment production, transport and deposition in rivers are part of the hydrological cycle. The amount and timing of sediments produced, the size and composition of sediment particles, and their transport in river channels are important characteristics of the sediment yield regime of drainage basins, which are sensitive to change. Darrell *et al*. (1999) collected and studied suspended sediment yield and water quality data in the Susquehanna, Potomac, Patuxent and Choptank rivers in the United States of America from 1985 to 1996. The highest sediment concentration was recorded in the Patuxent River, the highest sediment yield in the Potomac River, and the highest water discharge in the Susquehanna River. Jansson (1988) classified the suspended sediment yield of 1358 hydrometric stations, in drainage basins across the world that varied in area from 350 to 100 000 km^2, into five classes.

Accurate estimation of suspended sediment yield is necessary. The data used in this study were provided by the Ministry of Water Resources of Iran, which has collected information since 1961, and there are now 175 hydrometric stations present in the country. These data are used in erosion and sedimentation investigations, and are vital to research concerned with water resources management and in environmental studies.

The Soil Conservation and Watershed Management Research Center of Iran (2000) have suggested that the sediment yield of Iranian drainage basins has increased in the last three decades due to increased soil erosion and flooding. At present, there are many reservoirs in Iran which have sedimentation problems, including the Sefid-Rood Dam in the northern part of the country.

In the present study, temporal and spatial variations of suspended sediment yields in sub-catchments of the Daryacheh-Namak drainage basin, Iran, are investigated.

MATERIALS AND METHODS

The Daryacheh-Namak drainage basin is located between longitudes 48°5′ and 52°46′ E and latitudes 33°3′ to 36°45′N , and it is one of the largest drainage basins of the Great Kavir of Iran. It contains the important rivers of Jajrood, Karaj, Shoor, Vafraghan and Ghomrood, and has 20 hydrometric stations. The location of the Daryacheh-Namak drainage basin in Iran, its sub-catchments and the hydrometric stations are shown in Fig. 1. In the present study, sediment yield data from 10 hydrometric stations were investigated (Fig. 2). The criteria for choosing these hydrometric stations included a sufficient length of sediment record (at least 24 years), information covering major floods, and location upstream of large dams and away from areas of agricultural activity in the plains. The selected sites included Sarab-Hendeh and Khomein on the Ghomrood River and Yalfan, Saleh-Abad, Pole-Doab, Zehtaran, Bahador-Beik, Solan and Razin on the Ghareh-Chai River.

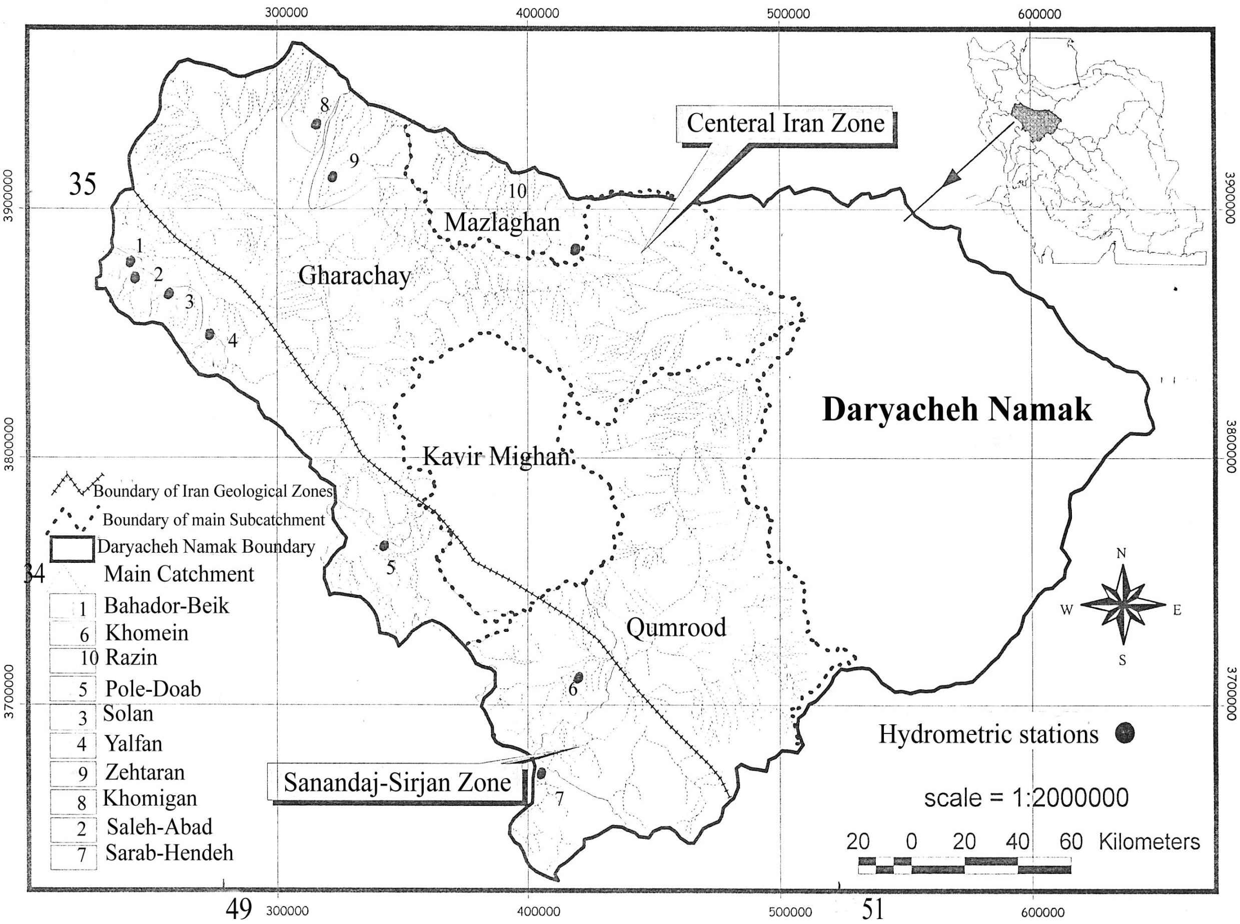

Fig. 1 The location of the study hydrometric stations (Jamab, 1999).

With respect to geology, the Daryacheh-Namak drainage basin is located in the three Iranian geological zones of Sanandaj-Sirjan, Central Iran and Alborz. The drainage basin is bounded by the Southern Alborz Mountains to the north and by the north-northeastern Zagros Mountains to the south. The present land uses in the drainage basin are agriculture, rangelands, forest lands, and bare lands. Mean annual precipitation ranges from less than 200 mm in the southeast to more than 800 mm in northern parts. Physiographic characteristics of the 10 study sub-catchments are listed in Table 1.

Table 1 Physiographic characteristics of the study subcatchments.

No .	Sub catchment	Area (km^2)	Perimeter (km)	Length (km)	Gravilius coefficient	Weighted mean slope (%)	Relief (m)	Mean elevation (m)	Weighted mean elevation (m)	Minimum elevation (m)	Length of main drainage (km)	Total length of main drainages (km)	The slope of main drainage (%)	Drainage density (km/ km^2)	Frequency of grade one drainage	Bifurication ratio	Mean annual precipitation (mm)	Mean annual temperature (°c)
1	Bahador beik	192	56.25	19.7	1.40	13.9	0.056	2900	2113	1790	12.2	160	3.43	0.8	25	5.02	350	8.45
2	Saleh Abad	242	55.75	21.5	1.14	22	0.07	3200	2241	1760	23.8	135	3.92	0.77	19.54	4.6	368	7.5
3	Solan	297	30	9.75	1.20	27.4	0.154	3400	2419	1900	12	45	5.56	1.1	36.34	4.5	399.4	6.16
4	Yalfan	177	61.25	20	1.14	26.7	0.08	3580	2466	1980	24.7	148.75	2.81	0.9	32.1	3.87	408	5.8
5	Pol Doab	1847	250	51	1.82	13	0.03	3324	2210	1773	65	1080	0.55	0.65	9.26	4.82	362.2	7.72
6	Khomein	2075	1040	35	1.17	9.3	0.041	3285	2185	1830	38.7	342.5	1.7	0.55	12.64	4.45	358	10.4
7	Sarab Hendeh	830	135.5	38	1.30	13.1	0.045	3724	2504	2000	50	455	1.1	0.54	13.74	3.7	414.5	8.12
8	Khomigan	455	67.5	25.7	1.18	4.79	0.042	2898	1678	1806	22.5	175	2.89	0.69	13.72	3.9	267.5	11.7
9	Zehtaran	1023	82.5	33	1.23	7.7	0.03	2713	2048	1744	37	201.25	1.29	0.48	9.52	3.44	333.3	8.94
10	Razin	1429	187.5	69.7	1.40	11.9	0.023	2944	1951	1300	75	722.5	1.05	0.44	7.55	3.5	316	9.17

Suspended sediment yield data for a 24-year period from 10 hydrometric stations were analysed using SPPS and Excel software to calculate mean monthly yields and average specific yield values.

RESULTS

The variation in average suspended sediment yield between the study stations is shown in Fig. 2, while the variation in average monthly yields, based on all stations, is depicted in Fig. 3. Yearly specific suspended sediment yield of subcatchments and mean yearly and peak water discharges are listed in Table 2. Monthly suspended sediment yields at the 10 hydrometric stations are detailed in Table 3.

The highest specific sediment yield (295 t/km^2/year) was associated with the Razin sub-catchment and the lowest (36.1 t/km^2/year) with the Solan sub-catchment. The stations in order of decreasing sediment yield are Razin, Khomein, Sarab-Hendeh,

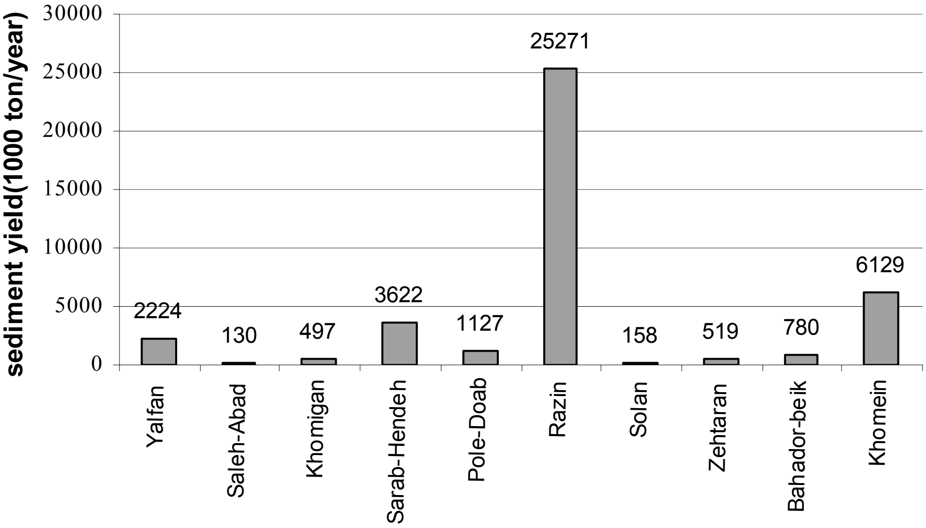

Fig. 2 Variation in suspended sediment yield between the study catchments.

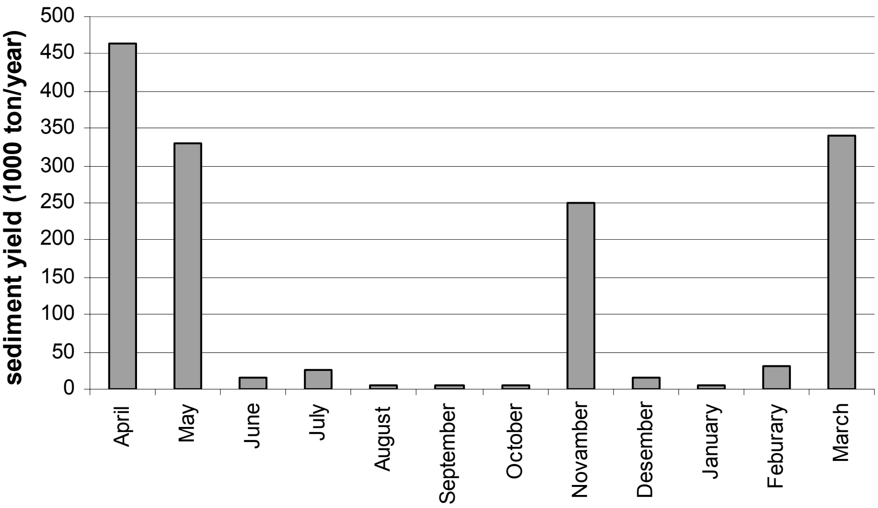

Fig. 3 Variation in monthly suspended sediment yield based on all the study stations.

Table 2 Hydrological characteristics and annual specific suspended sediment yield of the study stations.

No.	Subcatchment	Annual specific suspended sediment yield (ton/km^2/year)	Hydrological parameters: Mean annual water discharge (m^3/s)	Moment peak discharge (m^3/s)	Peak discharge (m^3/s)
1	Bahador-Beik	49.6	1.33	31.3	39.5
2	Saleh-Abad	178.5	0.74	22.1	44.4
3	Sulan	36.1	0.37	10.7	20.5
4	Yalfan	103.3	1.30	88.2	150
5	Pole-Doab	54.7	4.9	81.7	127
6	Khomein	226.2	0.91	14.7	26.6
7	Sarab-Hendeh	290.9	6.40	143	297.6
8	Khomigan	251.4	0.31	94.3	151
9	Zahtaran	142.9	0.50	42.1	43.9
10	Razin	295.0	2.35	82.3	190

Table 3 Annual and monthly suspended sediment yield at the study stations.

Month	Total for all stations (ton/year)	Yalfan	Saleh-Abad	Khom-igan	Sarab-Hendeh	Pole-Doab	Razin	Sulan	Zahtaran	Bahador-Beik	Khom-ein	Mean of all stations (ton/year)
April	465 776	6 897	3 250	2 253	86 435	9 990	349 326	261	3 121	3 294	948	16 578
May	326 360	45 552	29 105	6 197	14 855	3 471	208 128	2 366	7 310	12 681	6 695	36 636
June	7 232	2 780	551	19	768	35	2 541	288	87	160	3	723
July	18 403	185	0	0	88	22	18 050	45	10	1	2	1840.4
August	196	8	0	0	104	12	32	2	2	35	1	19.6
September	131	0	0	0	21	1	103	0	7	0	0	13.2
October	1 388	1 289	0	0	31	13	27	15	13	0	0	139
November	253 617	7 518	876	18	1 534	45	241 003	205	105	198	2 114	25 361.6
December	7 447	427	323	24	215	149	4 570	30	27	124	1 559	745
January	1 769	203	381	38	66	131	743	40	57	89	21	177
February	29 401	162	258	47	459	239	11 429	71	24	649	16 063	2 940.1
March	348 617	687	2 718	149	2 879	1 086	335 071	97	504	2 524	2 902	34 862
Yearly	1 470 334	65 709	37 465	8 744	107 452	15 193	1 171 023	3 420	11 266	19 754	30 308	147 033

Yalfan, Saleh-Abad, Pole-Doab, Bahador-Beik, Zehtaran, Khomigan and Solan. Figure 3 shows that suspended sediment yield in the Daryacheh-Namak drainage basin is highest in April and March, while the months of May and November have lower yields. Table 3 shows that, on average, suspended sediment yields were highest at the Razin Hydrometric Station in April (Mohammadi, 2003).

DISCUSSION

At Razin, the spring and summer seasons contribute 47.8 and 1.6% of the annual sediment transport, respectively. At Solan, the spring season contributed 85.2% and this was the season with most sediment yield at all stations except Khomein, where the autumn season accounted for 62.6% of the annual transport. Higher sediment yields in the spring mainly reflect the greater amount of rainfall in this season. Generally high sediment yields at Razin reflect significant land-use change in the sub-catchment, while low yields at Solan, are related to the wide occurrence in the subcatchment of resistant or relatively resistant geological formations and therefore sediment production is low (Mohammadi, 2003).

In the global specific sediment yield classification of Jansson (1988), the Razin, Sarab-Hendeh, Khomein, Khomigan, Saleh-Abbad, Zehtaran and Yalfan stations would fall into class 4, Pole-Doab, in class 3, and Bahador-Beik and Solan in class 2.

CONCLUSION

It can be concluded that large temporal and spatial variation of suspended sediment yield occurs in the Daryacheh-Namak drainage basin. The major controlling factors that influence this variation are rainfall, which is seasonal, land-use changes; and the erodability of geological formations.

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