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SUSPENDED SEDIMENT BUDGET OF A MEDITERANEAN WATER COURSE (THE CASE OF SEBDOU WADI, ALGERIA)

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The present work is about the sedimentary flux, produced by water erosion and carried in suspension in Sebdou wadi (North West of Algeria). We analyse the data of measures of the concentrations and liquid discharges. Nearly half of the total suspended load is transported in autumn, that is to say 125000 tons, for 5.3 millions of cubic meters of water inflow. In spring, the suspended load is estimated at 104000 tons for a liquid inflow of 18.3 millions of cubic meters , that it to say 3.5 more times than the autumnal inflow. We can note that 62% of suspended sediment load originate from the slopes and 38% from the banks and bed of the river.

1 Introduction

The various studies and researches devoted to the impoverishment of the soil by the means of the load out of front suspension revealed a high temporal and spacial disparity of these degradations in the south basins of the Mediterranean (Bourouba 1998; Demmak 1982; Ghorbal and Claude 1977; Heush and Milliès-Lacroix 1971; Megnounif et al. 2003 ; Probst et Amiotte-Suchet 1992; Sibari et al. 2001; Snoussi et al. 1990; TERFOUS et al. 2001). Specific degradations vary from 1000 to 5000 tons by km² and per annum. The volume of the sediments which are likely to deposit in the Algerian littoral is 47 million m^3 per annum. This study aims at quantifying the load in suspension measured during five years in the High-Tafna catchment area drained by the tributary Sebdou Wadi of the Tafna Wadi. This last one flows in the Algerian western northern littoral.

2 General presentation of the catchment area

Located in the Western North of Algerian and forming part of the catchment area of Tafna, the under basin High-Tafna upstream of Beni-Bahdel is arises in a more or less lengthened form and is spread out over a surface of 256 km^2 in a perimeter of 78 km (fig.1). The average altitude being 1058 m, and nearly 49% of the surface are slopes higher than 25%. The average uneven given by the index of slope of Roche is 0,077. This particularly faulted basin, is well drained by the Sebdou Wadi (High-Tafna), which originates in Ouled Ouriache and takes shape after a great number of ramifications dug in the Jurassic mainly carbonated soils which goes down from peaks reaching 1465 m. These ramifications meet on the level of the plain of Sebdou to 900 m in the plio-Quaternary alluvia. The wadi follows then its course in a steepsided valley (the ditch of Tafna), grows hollow in marno-limestones, limestones and Dolomies of Jurassic (Benest 1972 and Benast et al. 1999) to the dam of Beni-Bahdel.

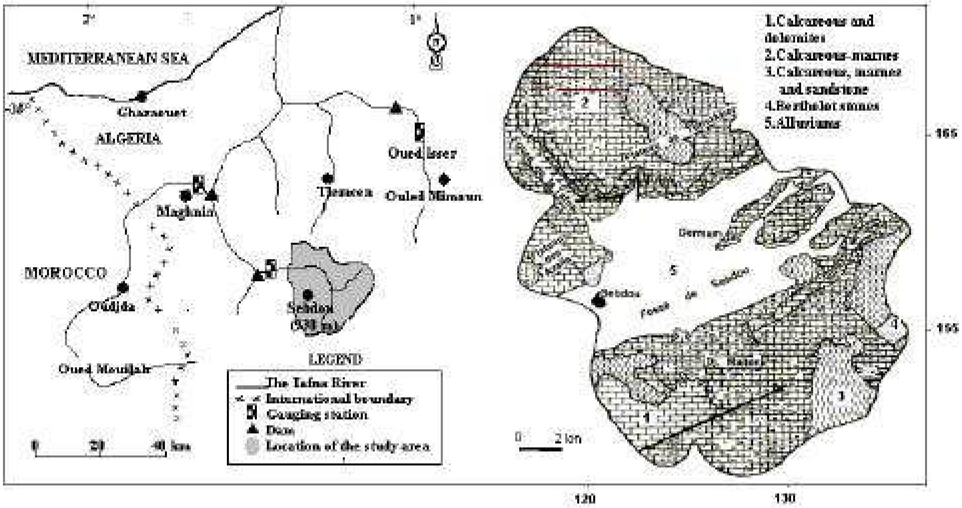

Figure 1. General Situation of the catchment area.

The High-Tafna catchment area, following the example of the Northern part of Algeria with semi-arid climate is characterized by a reduced number of rainy days and very unequally distributed during the hydrological cycle. Two to three months add up nearly 70% annual pluviometric height. Thus, this basin is characterized by a great variability of the annual pluviometric contributions. The coefficient of immoderation (quotient of the maximum pluviometric height to the minimal height) bordering the 4. Torrential downpours give up to 200 mm every 24 hours (Seltzer 1946). The summer storms sometimes exceed the 30 mm $hour^{-1}$ (Demmak 1982). As for the space distribution of precipitations, it is dictated by the maritime relief and influences (Bouanani et al. 2002 and Megnounif et al. 1999). The annual heights can reach the 1100 mm per annum on the slopes exposed to the wet winds coming from the North-West and decrease on the south facing slope inside the basin, where they vary between 200 and 800 mm.

3 Variation of sediment load and liquid discharge

the study focuses on 1257 instantaneous values of liquid flow and turbidity measured and provided by the services of the National Agency of the Hydrous Resources [A. N R. H.], and corresponding to takings from September 1988 to August 1993. Liquid flows Q_L, in m^3/s, are directly given by the rating curve according to the heights of water measured by a limnimetric ladder and a float liquid level recorder. Each time we read height of water, we take on the bank of the river, with a container, a charged water sample. The mud collected on a filter paper is weighed after drying with the drying oven at 105°C during 30 minutes. This enables to deduce the concentration C in g/l. The number of measurements and takings is adapted to the hydrological mode. The latter are carried out every two days and are intensified in period of floods. As for the majority of the rivers, one finds for the Sebdou Wadi a good relation in power linking the flow of the solid matters in suspension in kg/s to the liquid flow in m^3/s (fig.2).

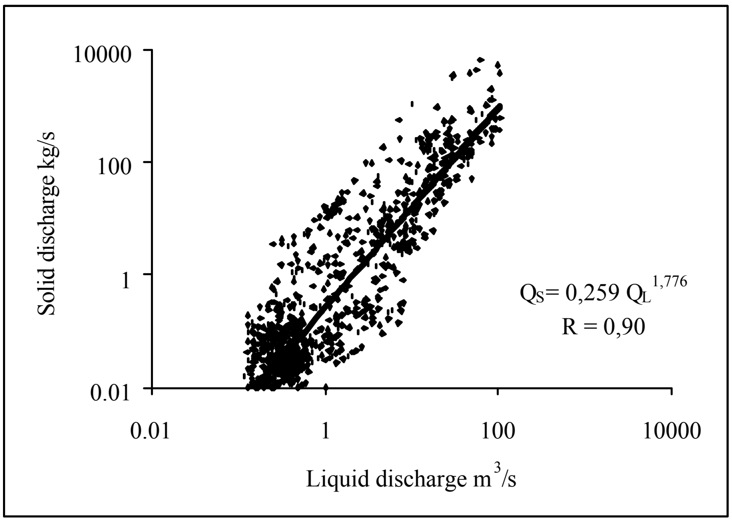

Figure 2. Variation of the concentration of the suspended sediment with the liquid discharge (September 1988 - August 1993).

In addition, the representation of the average curves linking these two parameters according to the various seasons (fig. 3), shows that the autumn is characterized by the moste charged liquid flows. Indeed, by their intensity, the first water rains tear off from the desiccated soils, great quantities of solid matters which will be carried by superficial run-off then transported in suspension by the river. In winter, and contrary to the other seasons, these two parameters narrowly evolve, we record a rather high coefficient of correlation (R = 0,84). In spring, the dilution of water by the contribution of the sheet of water is important. By this fact, load of water is tiny, it is less important than that of summer, the dry season, but where we observe intense storms which start short – lived floods but strongly charged, and thus the low coefficient of correlation.

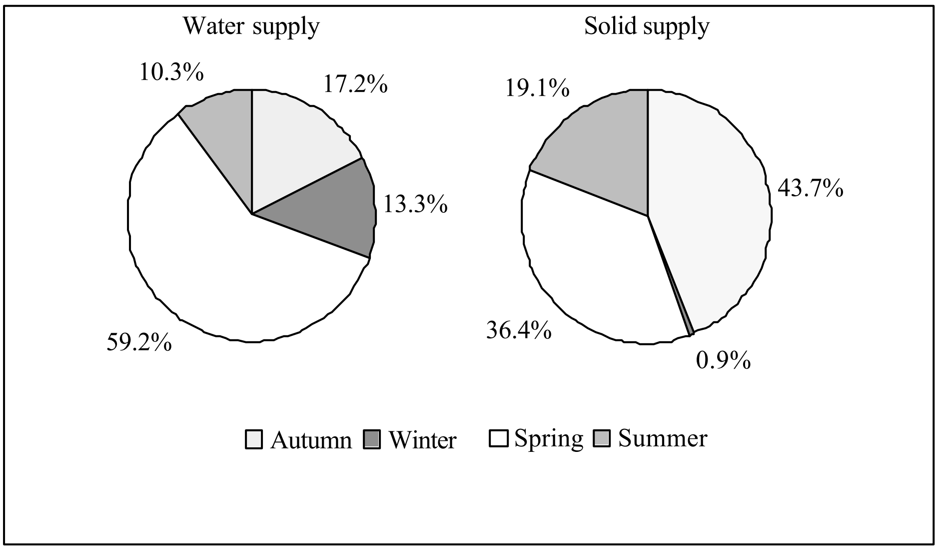

Figure 3. Average Curves binding concentration of suspended sediment with the liquid discharge following the various seasons (September 1988 - August 1993).

4 Budget of water and sediment contributions

The speed of the flows, due to the presence of steep reliefs and low in vegetable cover facilitates the capture of materials feeding the river transport. Over the five years of study, from September 1988 to August 1993, the river brought on annual average 286000 tons of sediments transported in suspension by 30,9 million m^3 of water. The water blade then represents 121 mm, that is to say a coefficient of flow of 29%. As for specific degradations they are about 1119 tons by km² and per year. The annual average of the solid load in suspension is about 9,6 g/l. It is also noted (Table 1), that the liquid and solid contributions are very variable from one year to another.

Table 1. Annual budget of : Precipitation P (mm); Liquid contribution A_L (106 m3); Solid contribution A_S (106 T); water height L_E (mm) and specific Degradation A_{SS} (T km-2 year-1). (September 1988 at August 1993).

Year	P (mm)	A_L (10^6 m^3)	A_S (10^6t)	L_E (mm)	A_{SS} (t.km^2.$year^{-1}$)
1988/89	355	23,7	0,274	92	1072
1989/90	352	10,9	0,014	43	53
1990/91	516	77,9	1,094	305	4283
1991/92	527	26,7	0,041	105	161
1992/93	345	15,1	0,006	59	24
Average	419	30,9	0,286	121	1119

With the seasonal scale, in spring, we record the most important contributions of water. They account for 60% of the annual supplies (fig.4). On the other hand, the autumn only contributes by 17%, but these waters are too charged, they reach 23,6 g/l on seasonal average. The sediment brought back by the river then represent a rate of 44% of annual flow. In winter, we can notice a clear fall of the liquid contributions, with a very weak production of sediments, nearly negligible. The load of water is about 0,6 g/l. The flows in good part are fed by the sheets of water. These ones contribute considerably until spring, during which, and in spite of the important dilution of water by the contributions of the underground flows, the load increases and passes to an average of 5,6 g/l. In summer, the dry season, we record the weakest water levels, until rupture of the flow. But the production of the sediments is far from being insignificant. Indeed, the area is characterized by summer storms , which start flows often short but charged. The average turbidity of water borders the 17,2 g/l. The flow of the sediments accounts for 19% of annual flow then.

5 The origin of sediments

The principal component of mechanical erosion is the surface run-off on the slopes. The water is then diluted in the river by the delayed, hypodermic and underground flows. However, at the time of its flow, water tears off from the bed and banks considerable quantities of solid particles which will be transported in suspension by the river. To understand these two mechanisms of erosion which regulate the transport of the solid matters in suspension, we applied the methodology recommended by Etchanchu (1988), Etchanchu and Probst (1986), Kattan et al (1987), Probst and Bazerbachi (1986). It is a method based on the decomposition of the flow hydrographs. It consists in separating the flows influenced by the surface run-off from those of the delayed flows. Apart from the periods influenced by the surface run-off, the flows are primarily fed by the delayed flows. The sediments transported by the river are mainly torn off from the bed and the banks. On figure 5, one can see that apart from these periods, there is a good linear relation binding the solid load to the liquid flow.

The extrapolation of the model found (fig.5) at the periods of floods influenced by the streamings, makes it possible to deduce the part from the sediments produced by the surface run-off on the slopes, and consequently, the one produced by erosion of the bed and the banks of the river.

For the Tafna Wadi, the part of the sediments eroded on the slopes by surface run-off and the one torn off from the hydrographic network, for the five years of study, are summarized in table 2.

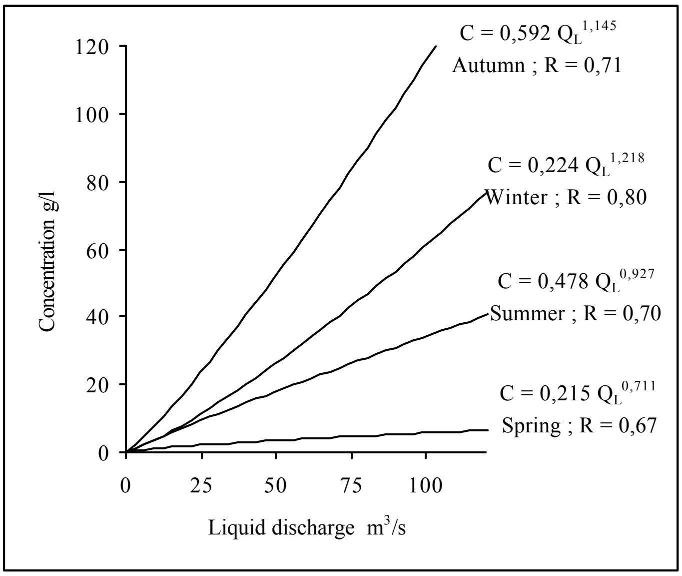

Figure 4. Average contribution of water and sediment according to the various seasons (September 1988 - August 1993).

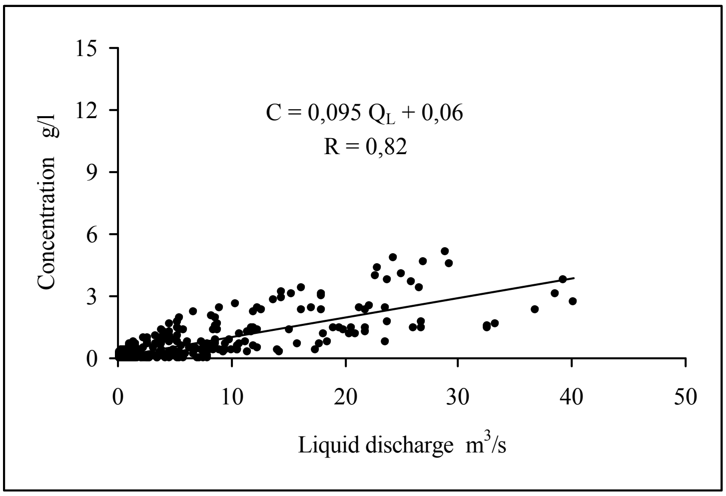

Figure 5. Relation between the sediment concentration and water discharge apart from the periods of floods (September 1988 - August 1993).

Table 2. Annual budget of the production of the sediments by surface run-off A_{SR} (10^6 tons), by erosion of the bed and the banks of the river A_{SLB} (10^6 tons), and their respective contributions.

Year	A_{SLB} (10^6 t)	A_{SR}(10^6 t)	Cont.A_{SLB}	Cont. A_{SR}
1988/89	0,018	0,255	6,7 %	93,3%
1989/90	0,005	0,008	40,0 %	60,0%
1990/91	0,466	0,629	42,5 %	57,5%
1991/92	0,020	0,021	49,5 %	50,5%
1992/93	0,003	0,003	49,8 %	50,2%
Average	0,103	0,183	37,7 %	62,3%

It results the following :

- For the Tafna Wadi upstream of Beni-Bahdel, the erosion of the bed and the banks is far from being negligible. It contributes by 103000 tons compared to the total production of the sediments exported in suspension by the river, that is to say a rate of contribution of 38%.
- This percentage is higher than those estimated between 13 and 22%, by Kattan et al.. (1987) for the river of Senegal, and with 24% given by Robinson (1977) for the rivers of the United States. On the other hand, it is evaluated respectively by Etchanchu and Probst (1986) between 30% and 53% for the Garonne in the south of France and by Duysings (1977) for a river in a wooded catchment area in Luxembourg.
- The component of the streaming in the production of the sediments is strongly marked in autumn. The solid contributions rise to 97000 tons, that is to say a specific degradation of the slopes estimated at 381 tons by km².
- In spring, the erosion of the bed and banks of the river is considerable. It is twice more important than the degradation of the slopes. It is about 71000 tons whereas the streamed load only represents 33000 tons.
- the summer storms are intense. They start streamings bringing back 51000 average tons of sediments starting from the slopes.

6 Conclusion

On an average annual flow of 286000 tons sediments transported in suspension by 30,9 million m^3, the contribution of the erosion of the bed and the banks is evaluated at 103000 tons, which accounts for 38% of the total solid contribution. The degradation of the slopes is then 62% that is to say 183000 tons, representing a specific degradation of 717 tons by km² and per year. Apart from the year 1988-1989, the rates of contribution of these two mechanisms of erosion in the production of the sediments remain remarkably constant year after year. They are about 46% for the erosion of the bed and the banks and 54% for the erosion of the slopes.

The production of the sediments is strong at the beginning of the autumn, but weak in spring. With an important contribution of sediments produced by the surface run-off on the slopes, the autumn is responsible for 44% of annual flow whereas the liquid contributions only account for 17%. On the other hand, spring adds up nearly 60% of the annual water throughput, but only produce 36% of sediment mainly torn off from the bed and banks. The summer storms are responsible for 19% of the annual throughput of the solid matters, into major part provided by the slopes.

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