

# Modeling of solid sediment transport in mountain rivers

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**Abstract.** In Algeria, the problems of erosion and sediment transport are critical, since they have the most dramatic consequences of the degradation of agricultural soils on the one hand and the siltation of the dam on the other. The sediment transport in the Algerian basins is very important especially during the periods of floods. It is in this sense that this study, which consists of estimating the sediment transport in suspension and determining the models of relation linking the liquid discharge and the sediment discharge in order to estimate the solid transport in the absence of suspended sediments concentration data at the Sidi Akkacha station at the outlet of the basin of Oued Allala which is subject to a high water erosion, it degrades from one year to the other under the effect of this phenomenon especially during the floods which drain high amounts of fine particles exceeding in general, the concentration of 150 g/l, the results obtained from the application of the models are very encouraging since the correlation between liquid and solid discharge exceeds 80 % .

## 1 Introduction

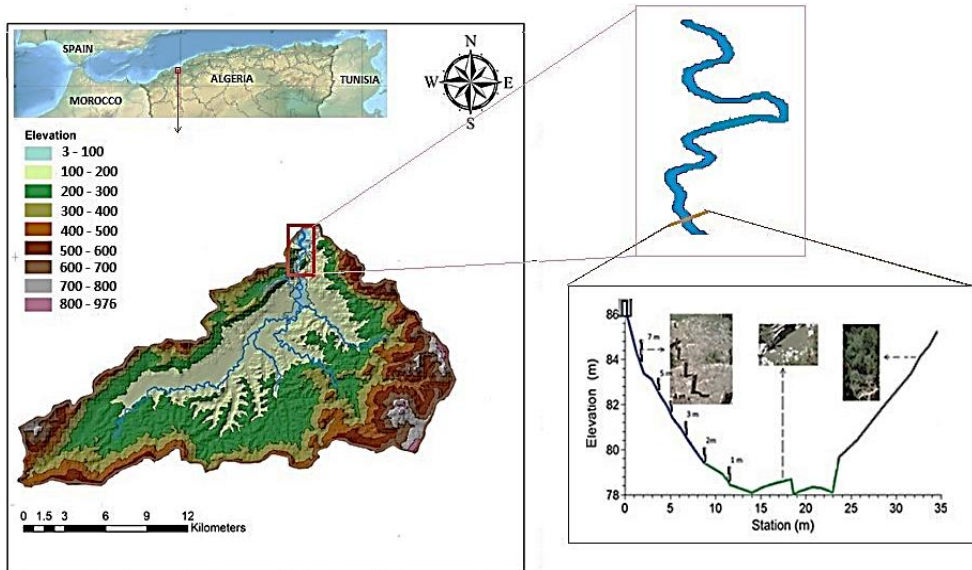
Erosion is a natural phenomenon that obeys the laws of physics and chemistry. "In a broad sense, erosion is a geological phenomenon of all times and places" [1]. Various authors [2, 3] (Remaoun) and (Wischmeier) have examined the processes of this scourge and the methods of the erosion quantification [4, 5], which indicates that a 30% decrease in the forest multiplies erosion by 5.L'. The specific annual erosion in the Algerian Basin varies between 2000 T/km<sup>2</sup> and 4000 T / km<sup>2</sup>, which makes Algeria one of the most vulnerable countries in the world [6]. Many researchers then developed relationships linking solid flow to liquid discharge for some Algerian basins [7, 8, 9, 10]. The main objective of our work is to develop a relation allowing to calculate the relation linking the solid and liquid discharge to quantify the solid transport in case of absence of measurement especially during the extreme floods for the watershed of Allala which is controlled at the outlet by the measurement stations of Sidi Akkacha [11].

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## 2 Presentation of the study area

The water catchment area of Oued Allala belongs to the group of coastal basins of Algeria, a relatively narrow littoral zone between the mouth of the Chelif and the zaccar massif, thus forming a relatively homogeneous Geographical Unit [12]. It covers an area of 296.34 km<sup>2</sup> and a perimeter of 94.36 km and with an average slope of 2.25 % and a main watercourse of 31.57 km that its average slope is 2.84% fig 1.



**Fig. 1.** Location of the allala Basin.

## 3 Hydrological data

The present study is based on instantaneous liquid discharge ( $\text{m}^3 / \text{s}$ ) and concentrations  $C(\text{g}/\text{l})$  where they are recorded at the gauging station of Sidi Akkacha, they were collected from the National Agency for Water Resources (NAWR). The data cover the period from 1982 to 2013. The liquid discharge are obtained in two ways on the basis of the rating curve and by counting the water heights recorded by the liminigraph. The sediment concentration measurement consists of systematic collection of water samples using a flask with a capacity of 500 cl, more samples are taken during periods of high water, while in low flow or when the liquid discharge is constant during the day [13]. the suspended solid discharge rate is given by the following formula :

$$QS = C Ql \quad (1)$$

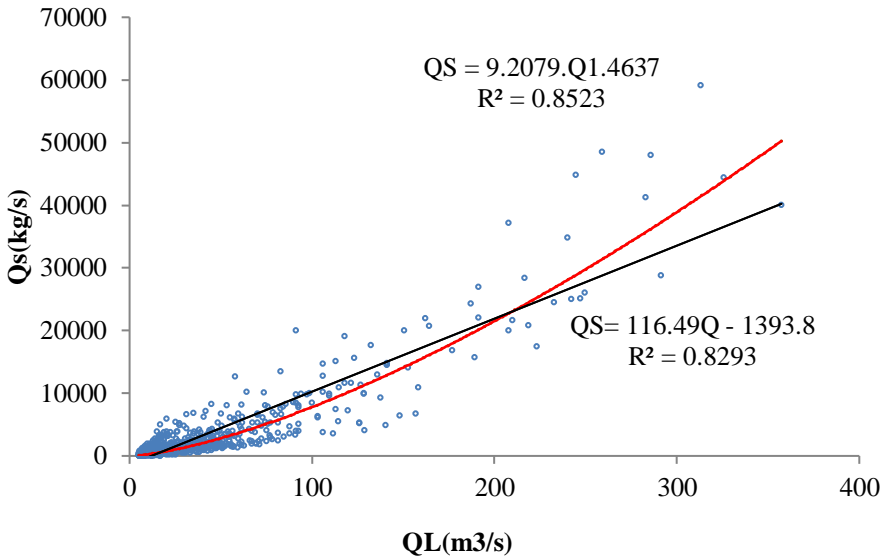
or QS is the solid discharge rate ( $\text{kg} / \text{s}$ ), C is the suspended sediment concentration ( $\text{g}/\text{l}$ ), and Ql is the liquid discharge rate ( $\text{m}^3/\text{s}$ ).

## 4 Results and discussion

Relationship between solid and liquid flow the power relationship [ $Qs = a Ql^b$ ] linking solid to liquid discharge developed by Kennedy(1985) has been tested and validated in many of the world's rivers [14, 15].

## 5 Annual report

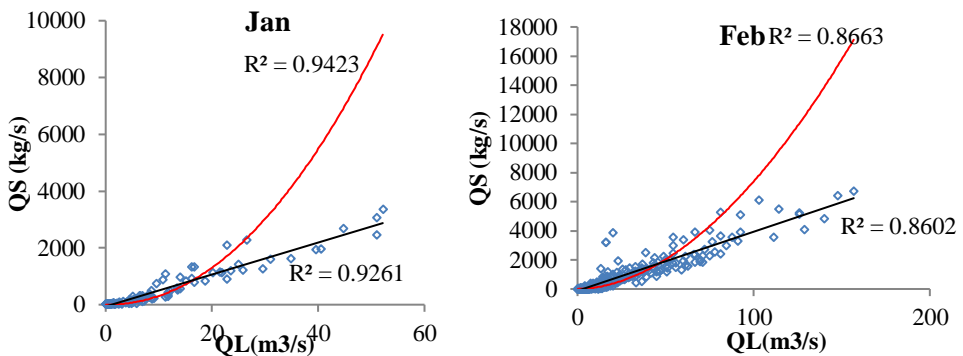
To study the development of sediment flows estimated from observed discharge and sediment concentrations, a temporal analysis at different scales (monthly, annual) was developed to find a mathematical model that could explain the relationship between liquid and solid discharge. Figure 2 show the correlation between annual liquid and solid discharge. After tests on the different types of adjustment based on the coefficient of determination, the power model gives the best fit with 85 % contribution for the period 1983 to 2013, we obtained the following relationship :  $Q_s = 9.2.Q_l^{1.4637}$ .

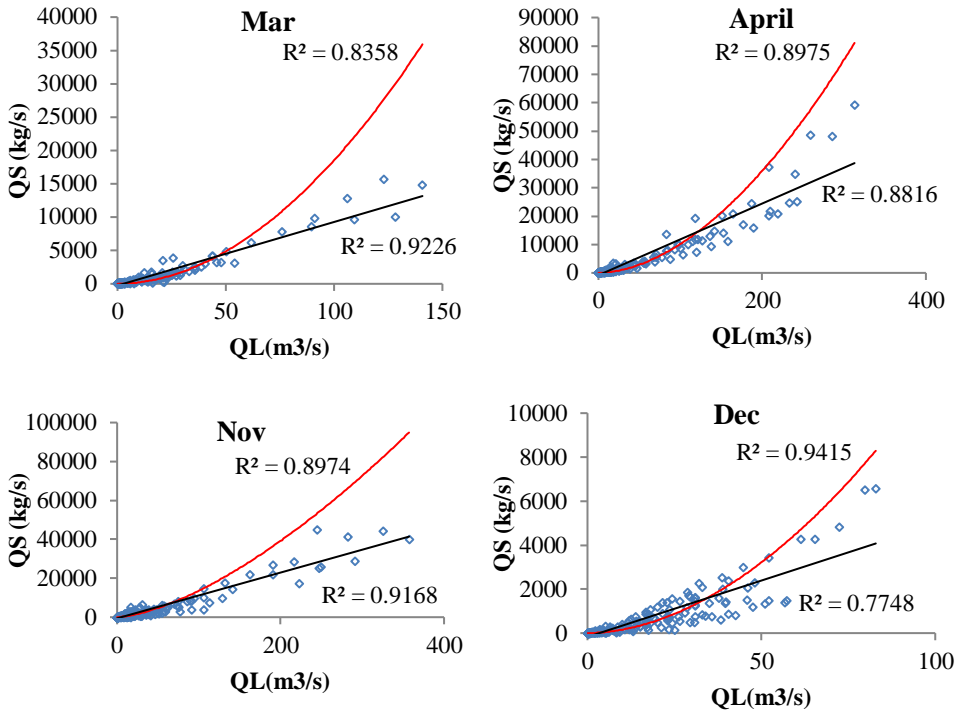


**Fig. 2.** Annual correlation between solid and liquid discharge (black liniaire model, red power model).

## 6 Monthly report

Another attempt of analysis would be a monthly analysis, at the monthly level correlations are better, because the variation of the solid transport in a month is not important compared to that variation in the year. the power model gives the best correlation with R2 over 90% almost every month. The figure 3 shows these relationships at the Sidi Akkacha station (January, February, March, April, November and December).





**Fig. 3.** Monthly correlation between solid and liquid discharge (black line model, red power model).

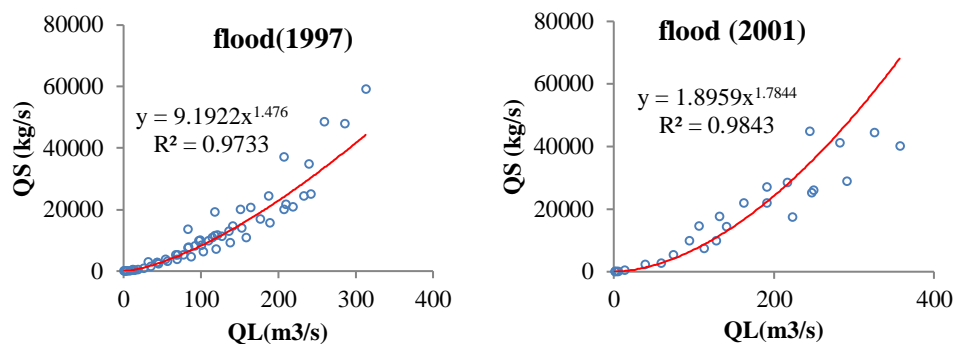
The results obtained by the adjustment are presented in Table 1.

**Table 1.** Model fit results at the monthly scale.

Time Scale	model type	$Q_s=f(Q)$	$R^2$
September	Linear	$Q_s = 139.05 Q - 845.87$	0.89
	power	$Q_s = 2.0827 Q^{1.9799}$	<b>0.88</b>
October	Linear	$Q_s = 134.39 Q - 71.996$	0.83
	power	$Q_s = 16.168 Q^{1.6813}$	<b>0.91</b>
November	Linear	$Q_s = 117.54 Q - 581.78$	0.91
	power	$Q_s = 12.15 Q^{1.5247}$	<b>0.89</b>
D�cembre	Linear	$Q_s = 51.257 Q - 173.92$	0.77
	power	$Q_s = 2.0993 Q^{1.8745}$	<b>0.94</b>
January	Linear	$Q_s = 56.294 Q - 63.548$	0.93
	power	$Q_s = 2.5956 Q^{2.0754}$	<b>0.94</b>
February	Linear	$Q_s = 40.567 Q - 124.4$	0.86
	power	$Q_s = 1.3656 Q^{1.8668}$	<b>0.87</b>
March	Linear	$Q_s = 95.301 Q - 256.01$	0.92
	power	$Q_s = 2.5149 Q^{1.9337}$	<b>0.84</b>
April	Linear	$Q_s = 126.29 Q - 815.31$	0.88
	power	$Q_s = 2.3492 Q^{1.8186}$	<b>0.9</b>
May	Linear	$Q_s = 66.056 Q - 82.749$	0.69
	power	$Q_s = 2.3415 Q^{1.9863}$	<b>0.88</b>

## 7 Relationship between solid and liquid discharge at the flood scale

The figure 4 shows the correlation of solid flow with liquid discharge during the floods of April 1997 and November 2001. We observe that the point cloud takes the form of a power function with a good correlation ( $R^2 = 0.98$ ).



**Fig. 4.** Correlation between solid and liquid discharge (flood 1997 and 2001).

## 8 Conclusion

In Algeria sediment control is essential for the management of Water Resources. It can be used to determine the effectiveness of sediment reduction actions in the watershed. Monthly-scale analysis of the relationship between solid and liquid discharge is highly descriptive of the semi-arid context of the Allala Basin. Indeed, the solid transport decreases in summer, increases from November to January, stabilizes in February and falls in March. The results obtained by applying the models are very encouraging because the coefficient of determination ranging from 84% to 98 %.

The model was used to estimate solid report in the absence of data on concentrations of suspended solids and to monitor observations and fill gaps. the basin of Oued Allala has a very high erodibility with an annual solid report between 34 105 and 35 106 tons / year.

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