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# Mathematical Approach to Water Erosion in the Catchment of the Wadi El Hammam and Their Impact on the Dams in the Region. (Algeria)

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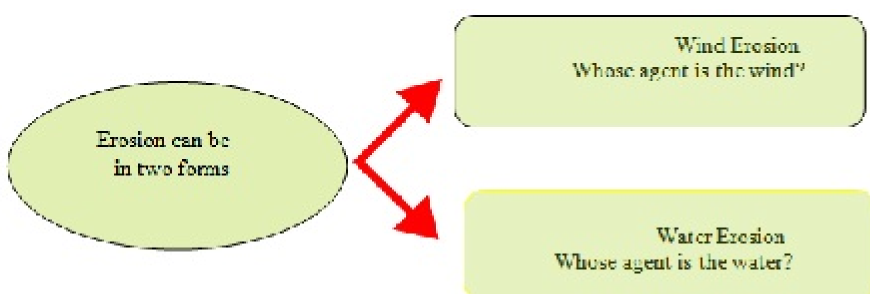
**Abstract:** The study of the solid transport of sediments, on a catchment's area scale, utilizes a great number of discipline and competences in fields which gather at the same time hydrologists, the geomorphologists, the agronomists, the mechanics of the fluids and the hydraulicians. The measurement of solid transport is only restricted with the suspension, haulage being expressed as a percentage estimated to start from the latter. In Algeria, solid transport is measured at the hydrometric stations of the basins slopes for the near total of the episodes of flow. Generally, one limits oneself to the flow in suspension. The measurement of haulage always represents a problem whose solution is not complete. The study on the catchment's area of wadi of Hammam (Algeria) has the aim of quantifying solid transport (in suspension and by haulage)[6] in this wadi which will be useful like a basic tool for the forecast of the quantity of the sediments posed in future reserves in this basin thus for installation of the wadis.

**Key words:** erosion, solid transport, catchment's area, haulage, suspension, Algeria.

## INTRODUCTION

The surface runoff carrying with them the proceeds of disaggregating rocks regions high to low-lying areas and ultimately to the sea[1]. This section is a brief introduction to the problems of the transport firm whose study has become essential in many areas; study processes of erosion and sedimentation[2]. The studies on pollution of rivers. In an attempt to mitigate the magnitude of these phenomena and try to act in an effective way to safeguard the physical environment, it is necessary to know and master the basic process. Once this knowledge gained, it is then possible to generate a model that quantifies the amount of sediment carried in the wadis and more specifically in our wadi which is of Wadi Hammam.

**2. Erosion:** As a general rule, soil erosion is the "posting" and "transport" of soil particles, by different agents (gravity, water, wind, and ice), their original location to a location "deposit "to downstream.




Water erosion is a widespread phenomenon; it can lead to irreversible losses of soil and siltation of dams and reducing their storage capacity[8].
Main agents of water erosion
Aggressiveness and intensity of precipitation
Degradation and detachment of soil particles resulting from the "work" performed by raindrops. Therefore linked to the kinetic energy of these drops Ec. There is an empirical relationship between the intensity of rainfall and its kinetic energy.

$Ec = 11.9 + 8.73 \log Ip$ '

Ec: Kinetic energy in j/m2/mm; Ip: rain intensity in mm / h.

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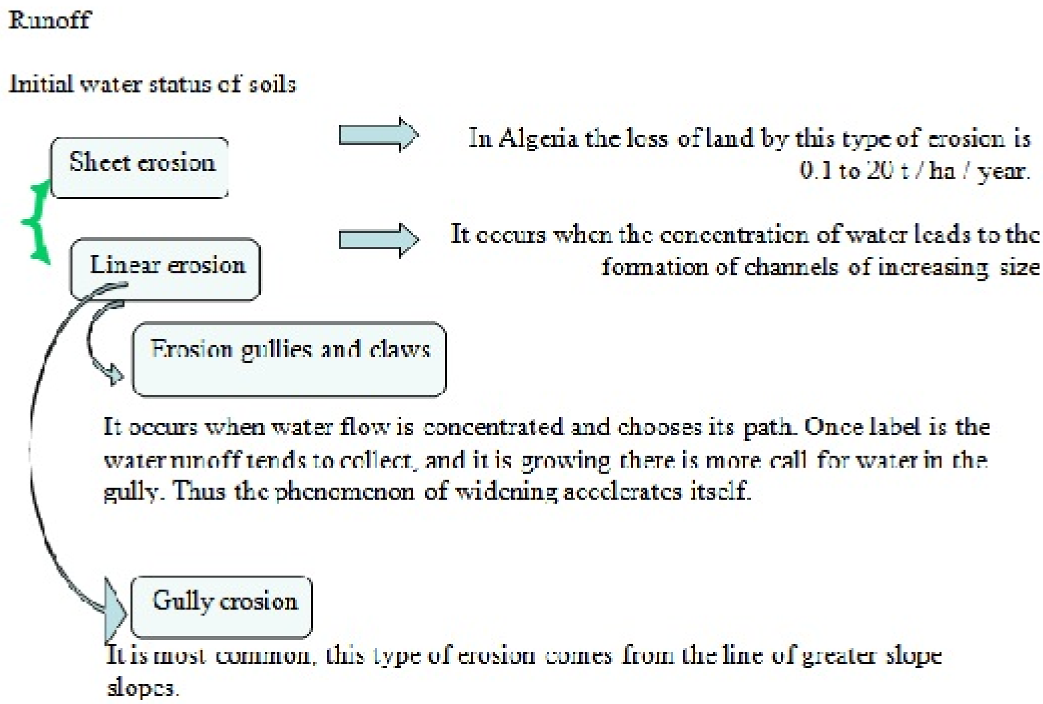
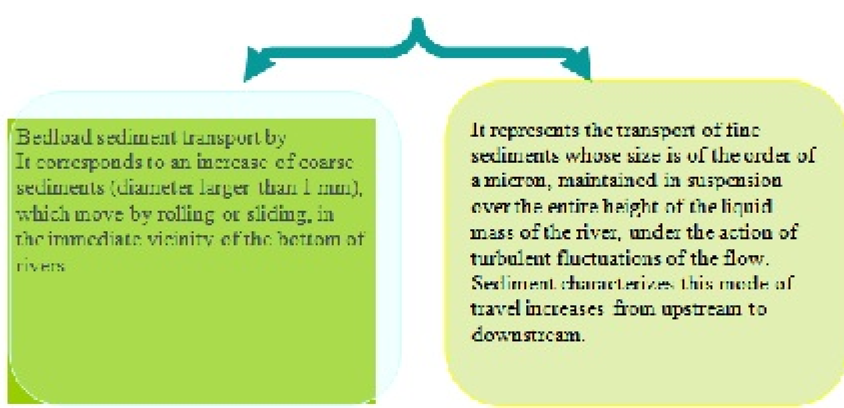



**Transport Solid:** Sediment transport which is essentially a runoff is the second phase of erosion. Depending on the size of sediment, have two distinct modes of sediment transport[9]:




3. Situation and Presentation parameters geomorphometric catchment's area of wadi Hammam:

The catchment's area of wadi Hammam is part of the great watershed of the Macta. It is bounded by the mountains of Beni-Chougrane north and the mass of Saida in the south. The catchment's area of wadi Hammam has very diverse natural environments, which justifies its dimensions: 3468 km2.

The wadi Hammam (Fig. 1a and Fig.1b) begins south of Saida. The accuracy of the surface and the perimeter of the watershed depend on the scale of the surface and density of the drainage network, over the latter factor is well marked, the delimitation is clearer and more calculating various is more or less precise.

The physical parameters and morph metric and indices slopes are
Illustrated in the following tables:

## MATERIALS AND METHODS

The station has Hacine measures water level and flow liquids from 1994 until 2002. Samples daily heights of water, whose frequency increases during periods of flooding, are made for the estimation of sediment transport. To collect different data, ANRH (National Agency for Water Resources)[3], was called


**Fig. 1a:** Situation catchment's area of Hammam

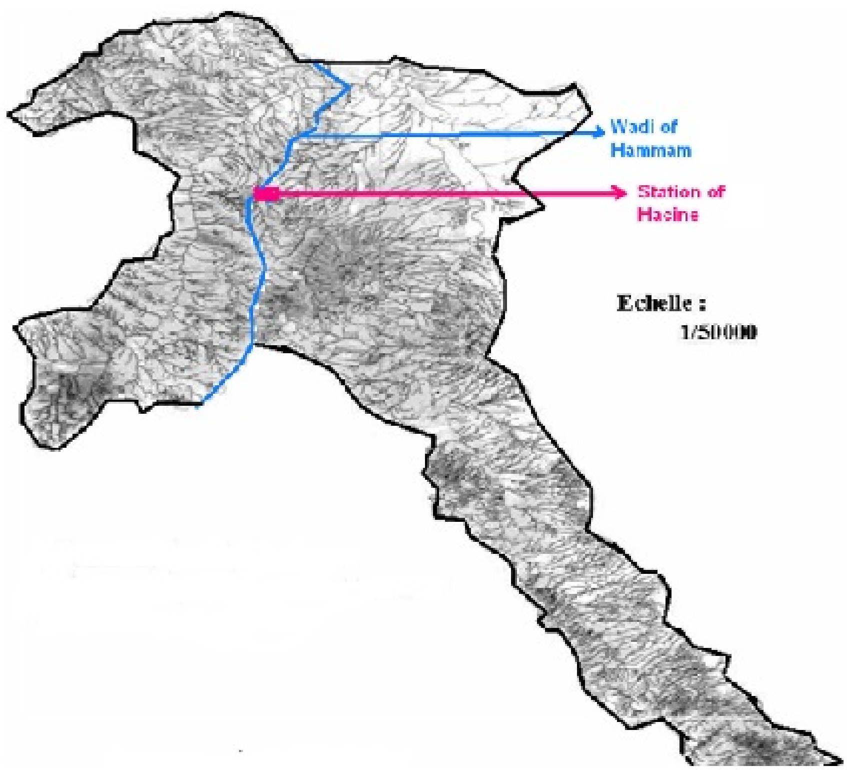



**Fig. 1b:** Map network Hydrographic Catchment's area of Wadi Hammam

**Table 1:** the index slope catchment's area of Wadi Hammam

| | Length L(Km) | heigh H5%(m) | heigh H95%(m) | heigh Hmax(m) | heigh Hmin(m) | Overall slope Ig% | Roche slope IR% | Average slope Imoy% |
|---|---|---|---|---|---|---|---|---|
| Catchment's Area of wadi Hammam | 113.51 | 1000 | 400 | 1050 | 175 | 0.52 | 0.32 | 0.77 |

**Table 2:** morph metric parameters of the catchment's of wadi Hammam

| | Gravity Drainage $D_d$(Km/Km²) | $F_s$ Frequency of rivers | $R_c$ Report of the confluence | $R_L$ Report of length | $C_t$ Coefficient of torentiality | $T_c$ Time concentration |
|---|---|---|---|---|---|---|
| catchment's area of wadi Hammam | 0.47 | 0.15 | 4.53 | 3.07 | 0.06 | 21 |

upon to make an inventory of all files related to transport solid support.

Relying on data from the ANRH, we have a series of 3014 values flow snapshots, concentration in the field from 01 January 1994 to January 1, 2002. The data obtained were classified by year or find the date of the levy, its time, its height in cm, the flow instant m³ / s and its concentration element suspended g / l. the introduction of all these data can have the sediment instant kg / s. It is given by the following:

## RESULTS AND DISCUSSIONS

$Q_s = C * Q_l$ equation 1

$Q_s$: the sediment [kg / s];
C: the concentration of suspended element [g / l];
$Q_l$: the liquid flow [m³ / s].

A station Hacine, we have a series of measurements from 1816 values heights of water (H cm), flow liquids ($Q_l$ m³ / s) and concentration of suspended solids (C g / l) (see Fig.2) were selected for the relationship between cash flow and the sediment and what remark concentration in the month May is more intense confirming the outbreak of floods in months of May.

The use of program A.N.R.H. "Concentrate / Bashyd" allowed us to get the sediment kg / s) for each arrivals levied on the basis of suspended solids observed, so the concentration is proportional to flow liquid which Fig.3 shows the flow solid is important and by the following relationship is determined that the sediment load:

$Qs = C * Q_l$ Model 1

For this work[4], we used a file containing the date, time, and the water level in cm, the liquid flow m³ / s, the concentration of suspended matter in g / l and the sediment kg / s of each of samples taken. The report cash flow concentration or liquid flow sediment was subjected to relations linear, logarithmic, polynomial, power and exponential[10]. It is reported that relations power and polynomial seem to give the best correlation coefficients. The good correlation can be explained by the effectiveness of the relationship that is to say that the sediment is a function of liquid flow on the equation (1). The liquid flow rates relations are solid and respected them can quantify and evaluate solid transport suspended in the wadi (see Fig.4).

For the calculation of solid transport daily suspension[5], using the characteristics of the correlation liquid sediment flow for the spring season. The calculation is done over a period of 9 years from 94 in 2002.

For the season of spring, the power relationship is of the form:

$Qs = 3.50 * Q_{l1.49}$ equation 2

and with R = 0.91.Ces latter being the main factor of solid transport.

The sampling was conducted on 03 sections. They were taken to the surface, along Wadi Hammam and more specifically endorsed by the station.

Where: D50 = 8mm (taking the average of 3 samples).

For the calculation of solid transport carried in Wadi of Hammam, we used the formula Shields whose conditions of applications are compatible with the rivers studied. The formula is:

$gs = 10 * q * J * (T0 - Tcr) / [(\rho s - \rho) -1]^2 * D50$ equation 3

Where:
gs is the sediment carried per unit width of the bed of the wadi [kg / cm];
> q is the daily cash flow [m³ / s];
> J is the average slope of the wadi, and is equal to 0,006 or 0.6%;
> $To = \gamma * a * Rh * I$ was forced to shear the average real (or coercion of friction dependent on the flow) [kg / m²];
> $Tcr = 0.06 * (\gamma s - \gamma) * D50$ is the constraint of shear on the bed [kg / m²];
> ρs is the density of sediment [t / m³];
> ρ is the density of water [t / m³];
> $D_{50}$ is the average diameter of sediment carried [m];
> γ is the weight of water [t / m³];
> γs is the weight of the sediment, taken equal to 2.7 t / m³;
> $a = (Ks / Kr)^{3/2}$ is a factor taking into account the roughness on the bed
wadi ;
>$R_h$ is the hydraulic radius [m];

In order to find a mathematical formulation explaining solid transport carried according to the liquid flow observed, we did the calculation for the case:

$To = \gamma * I * R_h$ ie a = 1 and $To = \gamma * R_h * I$ equation 4

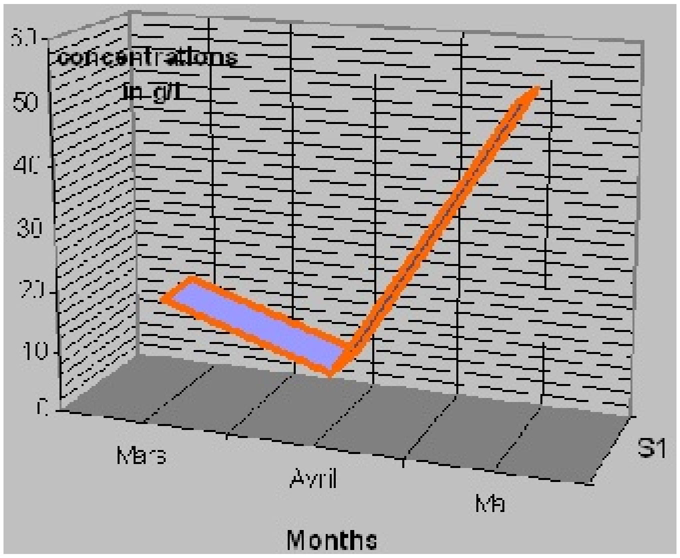



**Fig. 2:** The monthly variations Merger Along period (1994-2002)

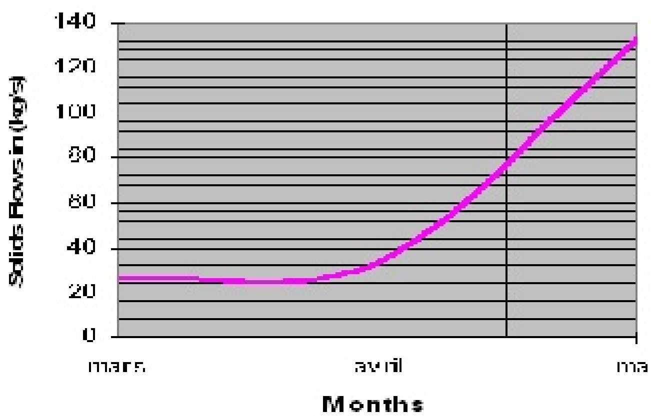



**Fig. 3:** Changes in rates in the solid spring season from period (1994-2002)

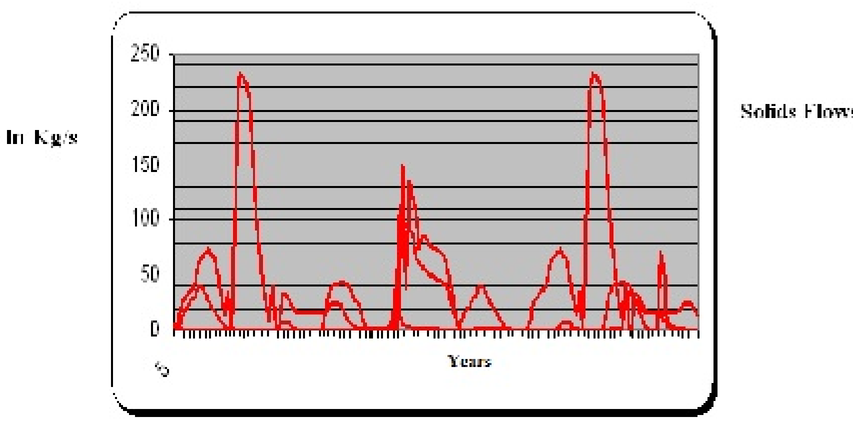



**Fig. 4:** Foreign exchange rates solid station Hacine period (1994-2002)

Based on the assumption that the series of spring is responsible for large amounts of sediment carried, we find this case a relationship between the sediment carried the flow of the liquid form:

$Gs = 0.88 * Q_{l1.17}$ equation 5

and with: R = 0.93.

Based on the relationship $Gs = 0.88 * Ql^{1.17}$, we calculate solid transport daily carried (Gs = gs * B where B is the width of the wadi) for the same period of 94 in 2002. The relationship between the sediment carried the liquid flow is a relationship of power in the form: $G's = 0.54 * Q_{l1.17}$ and with: R = 0.90

On the basis of the equation $G's = 0.54 * Q_{l1.17}$, another value of daily tonnage of materials carried assumed real, has been found. In calculating the total transport, it applies: Wt = Qs+ Gs and

W't = Qs + G's equation 6

Starting equations $Qs = f(Q_l)$, $Gs = f(Q_l)$ and $G's = f(Q_l)$, we have quantified the transport solid total annual tonne. Taking into consideration the total annual sediment transport real W't[7] , erosion averaged over a specific period of 9 years, is given by the following formula:

E's =W't / S equation 7

With:
E's: the rate of erosion specific [t / km$^2$. year];
W't: solid transport total [t];
S: the total catchment's area [Km$^2$].
Providing solid is estimated at 438265.88 m$^3$/year. (Wadi of Hammam).

**Table 3:** Results of the analysis size. Illustrates the results of the size analysis::

| section sampling | 1 | 2 | 3 |
|---|---|---|---|
| D50 [mm] | 9 | 4 | 14 |

**6. Conclusion:** During this study, we concluded that: A relationship is very significant, highlighting the report cash flow and the sediment suspended. It is the form $Qs = 3.5 * Q_{l1.49}$ with R = 0.92. Based on this relationship, we calculated the sediment suspended daily for a period of 9 years from 1993/1994 to 2001/2002. The results are found, and then transformed into annual tonnage of materia
ls in suspension.

Two relations, stressing report cash flow and the sediment load. They are like:

$Gs = 0.88 * Q_{l1.17}$ with R = 0.94, (the coefficient of roughness not taken into account);

$G's = 0.54 * Q_{l1.17}$ and: with R = 0.90, (the coefficient of roughness being taken into account).

Respectively, these two relations, we calculate the daily flow solid carried on throughout the reference period from 1993/1994 to 2001/2002 that we transform the subsequent annual tonnage load of coarse materials. The total volume of solid transport in the Wadi of Hammam right station Hacine is estimated by the total volume and suspended load. They are like:
Wt =Qs + Gs (where roughness in the bed of the wadi is negligible);
W't= Qs + G's (where the roughness in the bed of the wadi is not negligible).

From analysis of solid transport in the Wadi of Hammam, we deduct the following:

> The solid flow calculated daily carried a dry period are higher than those of suspension and flows during wet, we see the opposite;
> The sound carried annual flow are still below at speeds suspended solids;
> Load, where it would not take into account the coefficient patch roughness in the bed of the wadi, is estimated at 28% on average for the suspension, in the case we would take into account roughness of the bed of the wadi, the latter is estimated at 19% of the suspension. And at the end of this work, we can say that if one seeks to limit transport solid and the risks of silting, is in the most degraded and closest to the riverbed (correction rivers, river banks and streams) to be involved.

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