# EFFET DU DÉBIT SOLIDE SUR LA DURABILITÉ D'EXPLOITATION DE LA STATION DE POMPAGE DE ADJA (KHEMIS MILIANA, ALGÉRIE)

# THE EFFECT OF SOLID DISCHARGE ON THE OPERATIONAL SUSTAINABILITY OF THE ADJA PUMPING STATION (KHEMIS MILIANA, ALGERIA)

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**Résumé -** L'abrasion de la pompe est sans aucun doute la conséquence la plus sérieuse de l'érosion hydrique. Les effets indésirables de ce phénomène sont nombreux, allant d'une réduction considérable de l'efficacité de la pompe à la dégradation et à la conséquente diminution des performances de la station de pompage, comme c'est le cas de la station Adja située à Khemis Miliana, dans le nord de l'Algérie. Cette étude est basée sur le traitement statique d'un ensemble de données hydrométriques (débit liquide, concentration et débit solide) des deux bassins versants de Deurdeur et Cheliff Harbil, qui se déversent dans la station Adja située à l'entrée du bassin versant de Harreza. Les résultats des données de débit solide et liquide pour les trois bassins versants d'Oued Deurdeur, Cheliff Harbil et Harreza pour la période 1990-2011 ont montré une dispersion considérable. Les coefficients de corrélation ont été acceptables, à l'exception de l'Oued de Cheliff Harbil, en raison des difficultés rencontrées dans la mesure des deux paramètres, le débit liquide et la concentration des sédiments.
Le problème de l'abrasion de la pompe est dû à l'effet des sédiments transportés par le flux de l'oued Chellif, dont l'érosion spécifique a été évaluée à $3{,}31*10^6$ t/km$^2$/an. Cette valeur est due à plusieurs facteurs tels que l'absence de couverture végétale, la sécheresse et les caractéristiques morphologiques du bassin versant. Afin de minimiser le risque d'abrasion de la pompe, il aurait été nécessaire de construire une digue en amont de la station Adja.

**Mots - clés :** Abrasion des pompes, Oued Cheliff, Transport solide, Erosion hydrique, Efficacité de la pompe.

**Abstract -** Pump abrasion is undoubtedly the most serious consequence of water erosion. The adverse effects of this phenomenon are numerous, ranging from a considerable reduction in pump efficiency to degradation and consequent reduction in pumping station performance, as in the case of Adja station located in Khemis Miliana northern Algeria. This study was based on the static processing of hydrometric data sets (liquid flow, concentration, and solid flow) for the two catchments of Deurdeur and Cheliff Harbil, which discharge into the Adja station located at the entrance to the Harreza watershed. The results of the solid and liquid flow data for the three Oued Deurdeur, Cheliff Harbil, and Harreza catchments for the period 1990–2011 have shown considerable dispersion. The correlation coefficients have been acceptable, with the exception of Oued de Cheliff Harbil, which is due to the difficulties encountered in measuring the two parameters, liquid flow and sediment concentration. The problem of pump abrasion is due to the effect of sediment loaded in the flow of the Chellif wadi, whose specific erosion was evaluated at $3.31*10^6$ t/km$^2$/year. This value is due to several factors, such as the absence of vegetation cover, drought, and the morphological characteristics of the watershed. In order to minimize the risk of pump abrasion, it will have been necessary to build a river dike upstream of the Adja station.

**Keywords**: Pump abrasion, Oued Cheliff, solid transport, water erosion, pump efficiency.

## 1-Introduction

The presence of solid particles in water can accelerate wear and tear on pumps and other equipment, reducing their lifespan and increasing replacement costs [1]. The transport of solid materials in Algeria has been the subject of several studies. It is very high in Algerian rivers, but it is not well quantified in certain areas due to the absence or lack of monitoring equipment [2]. One study used statistical modeling based on liquid flows to estimate solid transport in the Oued Mekerra catchment in Algeria [3]. Another study focused on quantifying solid transport in the Chellif catchment in Algeria using statistical approaches and a calibration-validation model [4]. Sediment accumulation in Algerian dams is a growing concern, with over 650 million cubic meters of sediment deposited in more than 110 Algerian dams [2]. Quantifying solid transport in a river involves estimating the amount of sediment transported by the river. Various methods can be used to estimate this, including statistical analysis, fuzzy logic, and graphical analysis. Several examples can be cited, such as the quantification of suspended solid transport in the Labiod River in Algeria and its impact on the silting of the Foum El Gherza dam [5]. A new method for estimating suspended sediment flows at an Algerian dam (Beni Amrane dam) based on fuzzy logic [6]. In this paper, we will examine the impact of solid transport on the operation of the Adja pumping station in Khemis Miliana by analyzing the effect of sediments on pump abrasion.

## 2- Material And Methods

Khemis Miliana is located 145 kilometres south-west of Algiers, between 36° 15′ 55″ north and 1° 58′ 13″ east, and serves as a relay zone between east and west, north and south.


**Figure 1:** Zone d'étude

**Figure 1:** Study Area

### 2.1 Data acquisition and methodology

There are five (5) hydrometric stations spread over all the sub-catchment areas of the Upper Cheliff, with hydrometric time series varying between 1990 and 2011.

**Tableau 1:** Bassin versant de haut Cheliff

**Table 1**: Watershed of upper Cheliff

| Catchment | code of sub-catchment | Sub-catchment | Area ($Km^2$) |
|---|---|---|---|
| Upper Cheliff | 0114 | Oued Cheliff Ghrib | 1383.69 |
| | 0115 | Oued Cheliff Harbil | 767.29 |
| | 0116 | Oued Deurdeur | 857.64 |
| | 0117 | Oued Cheliff Harreza | 743.97 |
| | 0119 | Oued Rouina Zeddine | 898.54 |

The Tab.1 gives information on the sub-catchments concerned by the study.

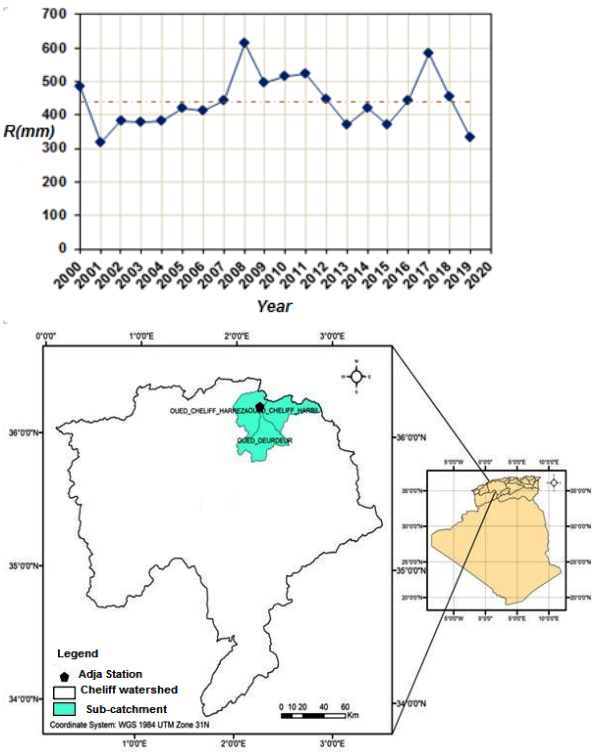



**Figure 2:** Variation des precipitations annuelles (2000-2019)

**Figure 2:** Variation in annual rainfall (2000-2019)

The Fig.2 represents averages over a 19-year period for the El Khemis station. The rainiest year at the Khemis Miliana station is 2008, while the driest year is 2001.

The basic data available are the average annual liquid flows in (m3 /s), and the average annual concentrations of suspended sediments in (g/l) collected on the Oued de Deurdeur at the hydrometric station under the code (011601) and the Oued de Cheliff Harbil (station 01154), by the National Water Resources Agency [7] of Blida. This database covers the period from 1990/91 to 2010/11, i.e. 21 years for the pairs (liquid flows $Q_l$ - suspended sediment concentrations C). The choice of this period was guided by data requirements linked to the hydrometric station, which has been shut down since 2011.

The average suspended sediment flow Qs through an average flow section is calculated as the product of the average suspended sediment concentration Cs and the average liquid flow Q over a given period of time:

$$Q_s = C_s * Q_l \quad (1)$$

The suspended sediment concentration Cs and the liquid flow rate generally evolve according to a power model $Y = aX^b$ [8][9][10].

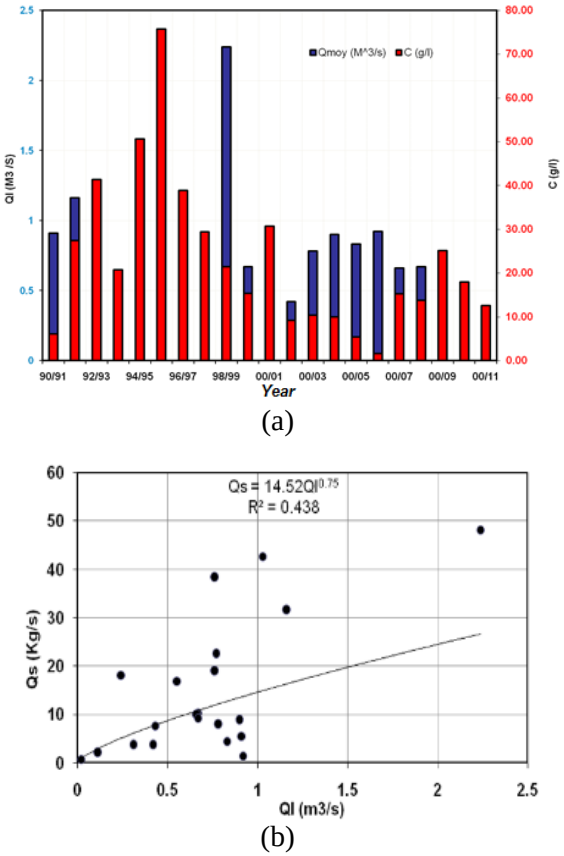


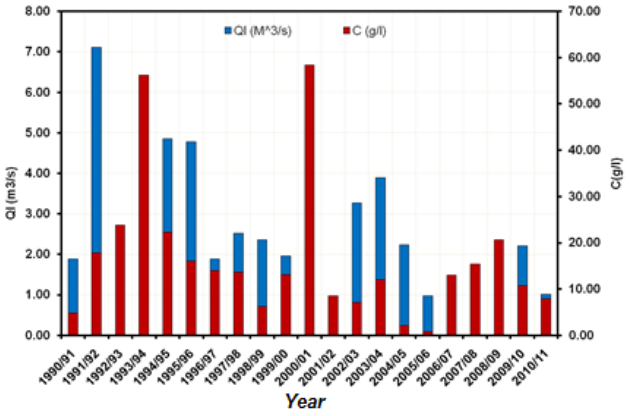

**Figure 3**: a) Variation des concentrations en fonction des débits liquides dans l'oued Deurdeur ; b) Relation entre les débits solides et les débits liquides sur l'oued Deurdeur.

**Figure 3**: a) Variation in concentrations with liquid flow rates in the Deurdeur wadi; b) Relationship between solid flows and liquid flows on the Deurdeur wadi

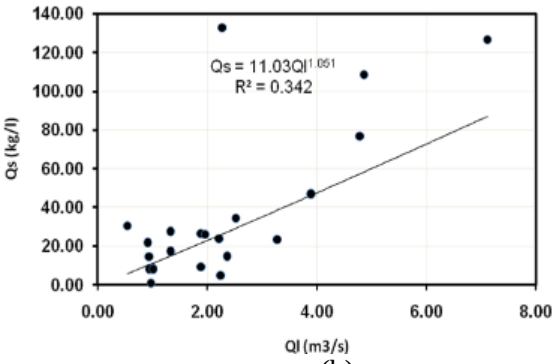
Fig. 3.a) shows that the concentration of sediments over the period 1990-2011 is considerable, especially in 1995 with a value of 75.67 g/l. This concentration is due to the absence of vegetation cover over the entire of watershed.

A statistical study showed that the points obtained could be reasonably fitted by a power law, with a correlation coefficient $R^2 = 0.438$. The equation is as follows:

$$Q_s = 14.52 Q_l^{10.75} \quad (2)$$




(a)




(b)

**Figure 4:** a) Variation des concentrations en fonction des débits liquides dans l'oued Chellif Harbil ; b) Relation entre les débits solides et les débits liquides sur l'oued Chellif Harbil.

**Figure 4:** a) Variation in concentrations with liquid flow rates in the Chellif Harbil wadi; b) Relationship between solid flows and liquid flows on the Chellif Harbil wadi

Fig 4.a) shows a rather low concentration compared to Deurdeur, where the year 2001 was recorded at 58.38 g/l, although this year was considered the worst. It should be noted that the vegetation cover better protects the watershed than the Deurdeur watershed, where the relationship between Qs and $Q_l$ best explains the case.

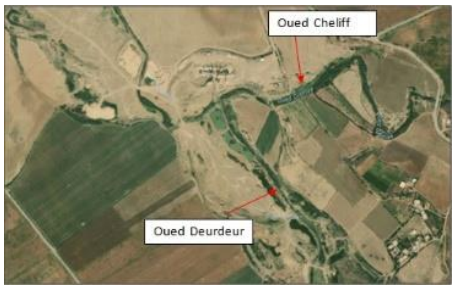
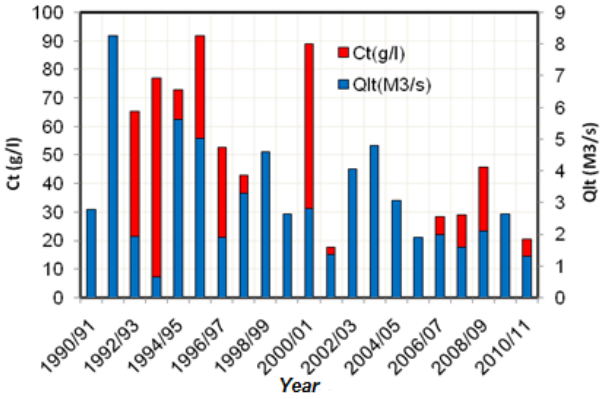
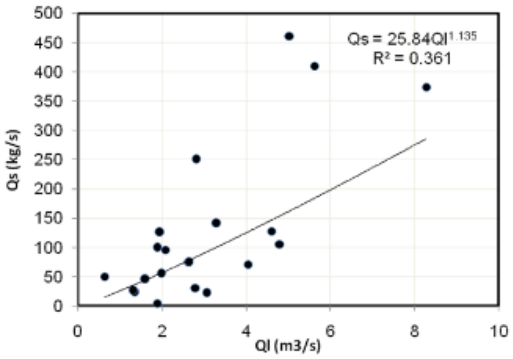



**Figure 5:** Le point de rencontre de l'Oued Deurdeur avec l'Oued Cheliff

**Figure 5:** The meeting point of Oued Deurdeur with Oued Cheliff




(a)




(b)

**Figure 6:** a) Variation des concentrations en fonction des débits liquides dans l'oued Chelliff ; b) Relation entre les débits solides et les débits liquides sur l'oued Chelliff.

**Figure 6:** a) Variation in concentrations with liquid flow rates in the Chelliff wadi; b) Relationship between solid flows and liquid flows on the Chelliff wadi

The two wadis discharge into the Adja station Fig.5, i.e. a high sediment concentration and consequently a high solids flow, which has an impact on the performance of the station itself. Two high C values have been recorded, the first in 1995 with a value of 91.68 g/l, corresponding to a liquid flow of 5.02 m3/s.

The second was in 2001, with a value of 89.11 g/l, corresponding to a very low flow of 2.82 $m^3/s$, which coincided with the drought period.

We quantified the total solid transport $Q_{ST}$, at the Adja station, which represents the sum of the annual suspended solid transport Qs and the solid transport by scour Gs , over the period from 1990 to 2011 (table in Appendices). Carriage was taken to be equal to 34% of the suspended solid flow [11].

Evaluating the rate of erosion

Annual surface degradation is the total solid load, accumulated over one year, divided by the surface area of the contributing catchment:

$$E_s = \frac{A_s}{A} \quad (3)$$

With: Es annual surface degradation ($t.km^{-2}.an^{-1}$), $A_s$ annual solid input in tones (t) and A catchment area in ($km^2$).

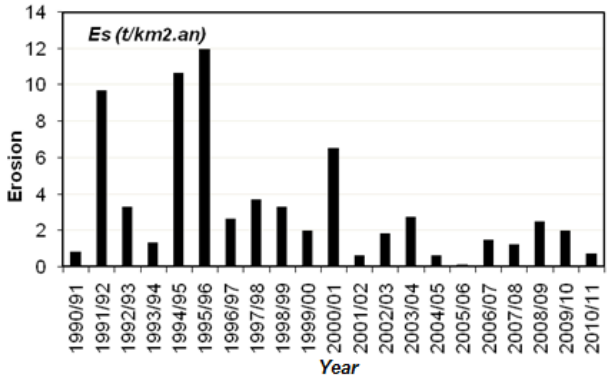



**Figure 5**: Variation annuelle de l'érosion spécifique

**Figure 5**: Annual variation in specific erosion

**2.2 Effect of specific erosion in the abrasion of pumps at the Adja station**

According to the data provided by ANRH for the year 2011, we estimate that the data between 2011 and 2019 correspond to an average erosion rate estimated at $1.41.10^6$ $t/km^2.year$.

**2.3 Specific erosion rate**

Evaluation of the erosion rate over the period 1990-2011 gave an annual average of around 3.43 $Mm^3$. This monstrous quantity can cause abrasion to incoming pumps as it passes directly through the station during the entire flood period.

The absence of measurements from 2011 to the present has forced us to estimate an average of 1.41T/ $km^2$.year.

The great risk of erosion in suspension in the abrasion of the pumps, in particular the impellers, which are confronted by the high speed of the water current loaded with solid particles, something that reduces the lifespan of these pumps, as in the case of the four pumps that are at a standstill to date shown in Fig. 7. The non-operation of these pumps is considered an economic loss and has repercussions on the performance of the station itself.

This situation presents the operator with a problem that degrades the pumps and affects their performance. This scourge requires a solution to protect these pumps against the phenomenon of abrasion.

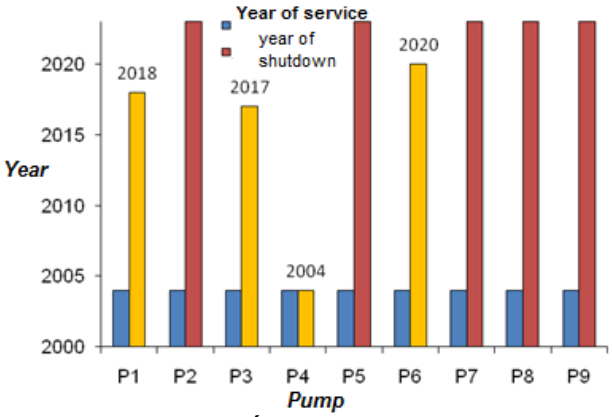



**Figure7**: État des pompes

**Figure7**: Pumps status

## 3- Discussions

Plotting the solid and liquid flow data for the three catchment areas of Oued Deurdeur, Cheliff Harbil and Harreza for the period 1990-2011 shows considerable dispersion.
From Figures 2.a), 3.a), and 5.a), the correlation coefficients [ $R = \sqrt{R^2}$ ] are respectively: 0.66; 0.58; 0.60.
From these correlation coefficients, we can see that there is a considerable correlation between the solid flow and the liquid flow, except for the value for the Cheliff Harbil basin, which shows a correlation of 0.58. This value would mean that it is difficult to measure the two parameters in this basin.
The correlation between solid and liquid flow is obscured by the sudden influx of sediment caused by occasional rainfall during dry periods and by the first outbreaks [12].

## 4-Conclusion

This study consisted of a diagnostic study of the Adja water pumping station, located in Khemis Miliana, Algeria. The aim was to identify the station's hydraulic and technical problems and propose solutions to improve its performance. It was found that there was a wide dispersion of data on solid and liquid flows in the surrounding catchment areas. Solid transport in Wadi Chellif, at the entrance to the station, was estimated at $3.31*10^6$ t/km2/year for the period 1990–2011. This is due to various factors, such as the lack of vegetation cover and the morphological characteristics of the catchment. To mitigate the risks associated with solid transport, we have recommended the use of filter screens, regular pump maintenance, and the construction of a river embankment upstream of the station. Further research is needed to better quantify and understand solid transport in Algerian rivers. In conclusion, appropriate measures are essential to protect pumping stations and ensure their smooth operation.

## Acknowledgment

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