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Hydro-Geoenvironmental Analysis by the Study of Surface Sediments: Case of Wadi Elguelta, Ouardanine, Tunisia.

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Abstract:
Background*:The choice of wadi Elguelta makes it possible to study the effect of anthropization, lithology, geomorphology and hydrology on the composition of the surface sediments of the area. In order to establish this relationship, outcrop samples were taken from the soils at seven different points. The choice of places took into consideration their position in relation to the minor bed of the Wadi Elguelta '.*
Materials and Methods*: Various measurements were carried out such as: the pH, the electrical conductivity, the organic matter content as well as the mineral element concentration.*
Results*: Results showed that the conjunction of different factors (geological, geo-morphological and anthropogenic) increased the measured values. Moreover, we have tried to interfere the factors and present them in a synthetic sketch. Finally, we presented some recommendations to reduce the values and restore the geo-morphological shape of the Wadi and especially to clean the riparian zone (riparian zone).*
Conclusion: *The 'Wadi Elguelta' is a model of the small watersheds of eastern Tunisia suffering from strong anthropization and weakened by strong water erosion. His study goes into obtaining a database of the region. Local and regional intervention is highly recommended to preserve its ecology and the geo-morphological forms of these relief units. The human footprint remains highly personalized in the study area.*
Key Word*: small watersheds; sediment; riparian zone; hydromorphology; anthropization.*

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I. Introduction

'Wadi Elguelta' surrounds 'Ouardanine' region which is the hinterland of Monastir. It has always been a water resource to supply the surrounding fields. Its exploitation remains intensive. In recent years, the 'Wadi Elguelta' has been a place for wading. Immediate releases (either demoestic or otherwise) combined with a shortage of water catalyze the concentrations of chemical elements. The commune of 'Ouerdanine', like any other commune in the Tunisian Sahel, has a real problem in the need for irrigation water. Resorting to unconventional resources is a remedy. Wastewater treatment is an asset in alleviating the water shortage. In this same context, the 'Wadi Elguelta' represents not only a collector of rainwater from its basin but also an outlet for treated water**.** The idea of analyzing the sediment of this stream is to assess its degree of mutation due to strong anthropization. According to Dbara and Lahmar (2021) the use of treated wastewater in irrigation alters the physicochemical characteristics of the soil. Indeed, these modifications are manifested by an increase in the electrical conductivity, the pH as well as the contents of organic matter and mineral elements. Likewise, it has been reported in several studies that the treated wastewater affects the concentration of heavy metals in the soil (Selmi, 2007). Also, the geomorphological profile could be affected (Oueslati, 2016). The present work consists on the determination of the physicochemical characteristics of the sediments in minor bed, intermediate level and exceptional major bed of the 'Wadi Elguelta'. Different sampling points will be compared to detect the effect of the modifications that have affected this watercourse.

II. Material And Methods

Study area

The present research was performed in the 'Ouardanine' region which belongs to the Monastir governorate. It is located in the central East of Tunisia (Figure 1).

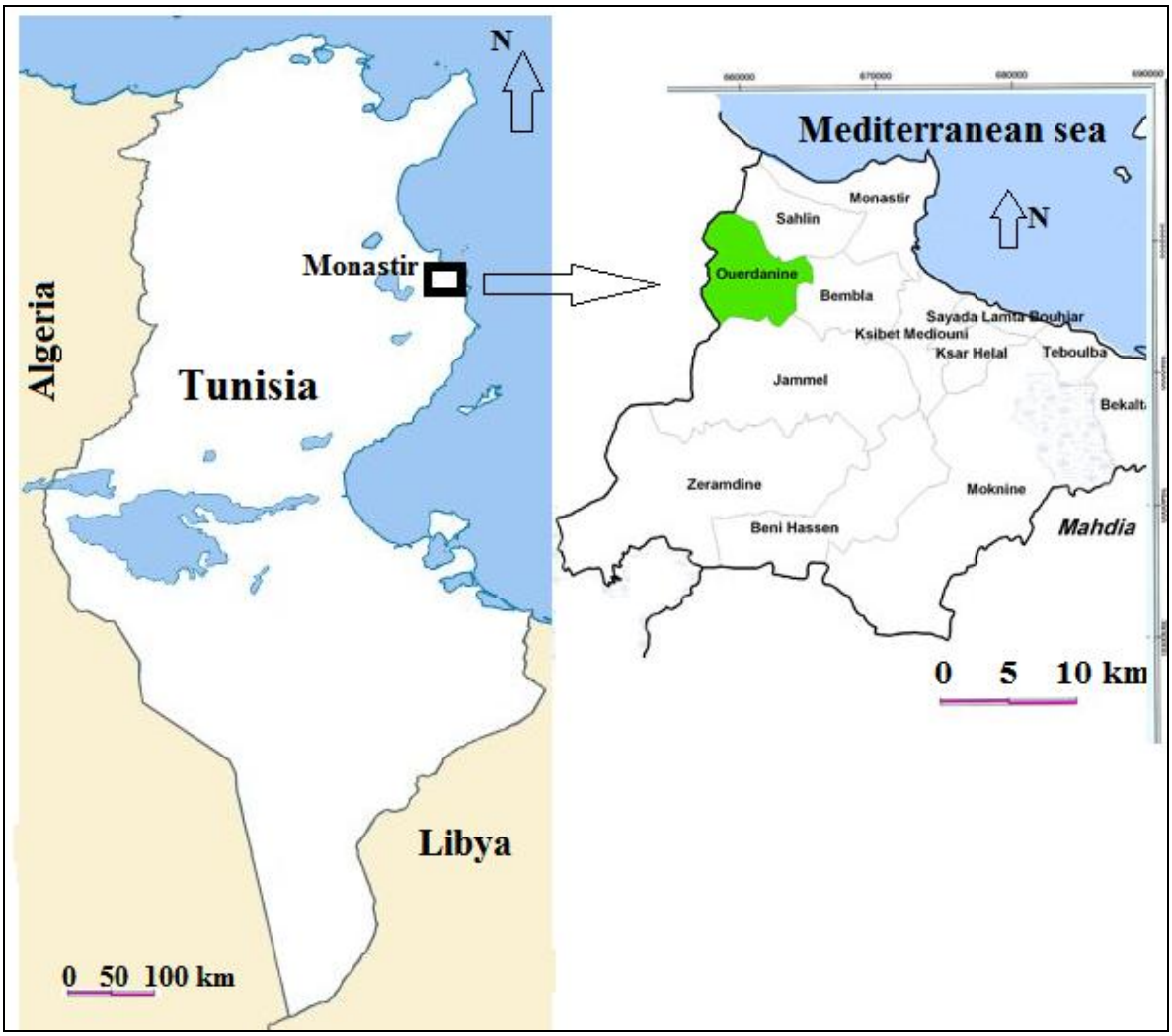

Figure n°1: The localization of study area.

The 'Wadi Elguelta' is one of the main rivers of the zone (Figure 2). It is characterized by a strong anthropization which consists on water passage of treated waste water from the basin of 'Ouardanine' managed by the National Office of Sanitation (ONAS). Consequently, an important irrigated perimeter was developed in the region.

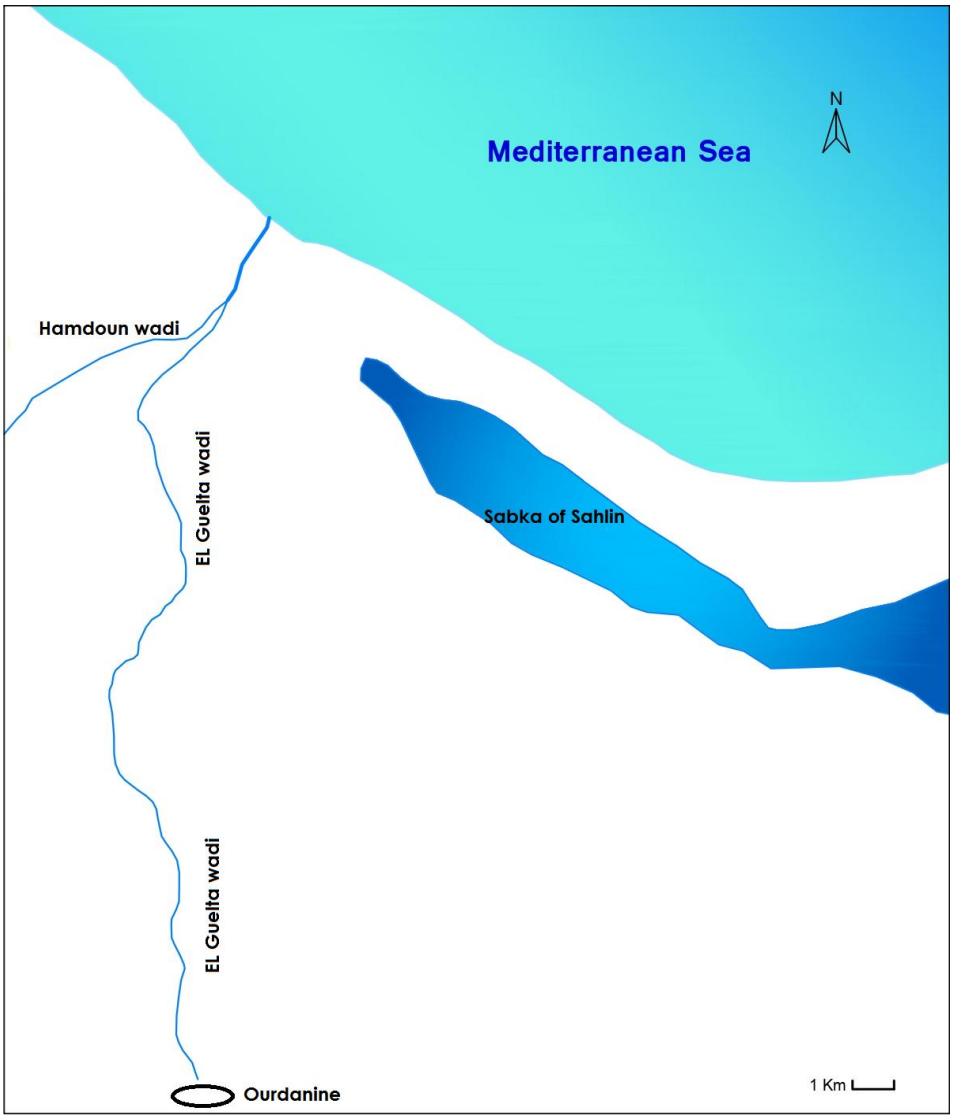

Figure n°2: The localization of the 'Wadi Elguelta'.

The climate is of the semi arid characterized by warm winter and dry summers. The average temperature is of 19.4 °C and the annual precipitation is of 353.7 mm.

Geological overview of the study area

The region is characterized by varied formations ranging from the Miocene to the late Quaternary generating different types of environments. The dominant rocks, 1500 m thick, occupy the core of the anticline domes. The latter characterize the geological formations of 'Ouerdanine'. They are made up of an alternative series ranging from sandy clay, clays, sand to shell sandstone. The domes are therefore made up of soft rocks with an intensely gullied dip. The highest point of these registers 176m which are often separated by a depression or basin.

Quaternary formations, much less thick, are most often encrusted (continental formations of the Villafranchian and Middle Quaternary). The limestone crust (less than 10 m thick) occupies a dominant position in the 'Ouerdanine' landscape. It plays the role of an impluvium by its compact and coherent character and its position on the ridges. This specificity favors the concentration of the flows (Slim and al, 2004).

Sediments sampling:

For sampling, a number of seven points was marked according to their wadi proximity (Figure 3). The choice was based on the probably variation of sediment properties. For each point, samples were taken from the horizon 0-20 cm with three repetitions. So, a total of 21 samples were picked up and bring to the laboratory for analyzes.

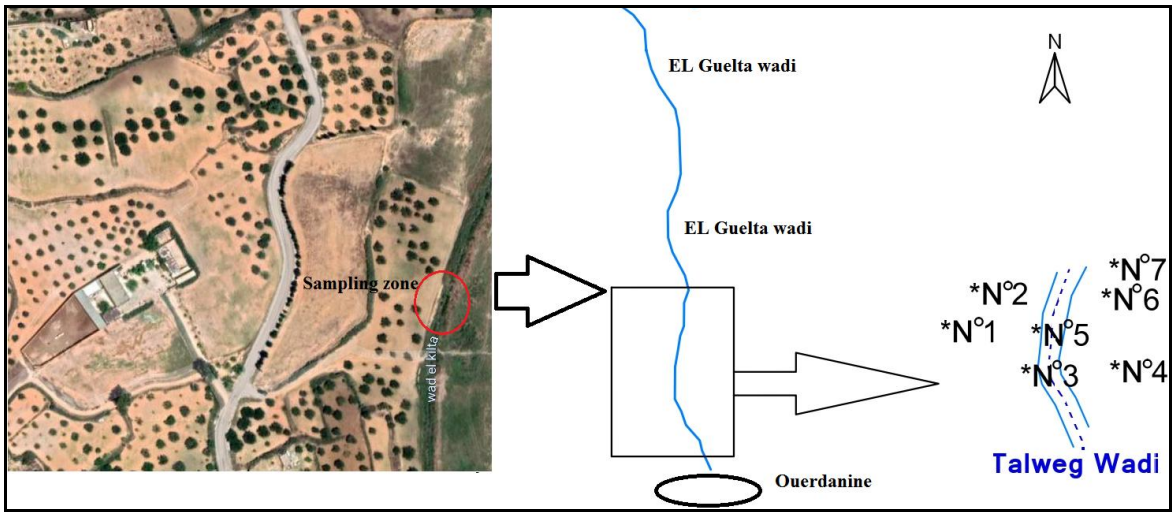

Figure n°3: The localization of different points sampling.

Samples are grayish and reddish in color. The sand rate is very high. It is between 45% in the sample (6.7), 55% in the sample (2.3) then 60% in sample 5 and it exceeds 70% in the sample (1.4)

Sediments analyzes:

pH and conductivity measurements

The pH was determinate using a pH meter (Milwaukee) and the electric conductivity (EC) using a Conductimeter (JENWAY®).

Organic matter

To a 0.2 g of the soil 5 ml of potassium dichromate and 10 ml of sulfuric acid were added and after stirring for 30 min 25 ml of distilled water were added, then after a final stirring, it was left to stand overnight to read on a spectrophotometer (BioBASE) at a wavelength of 600 nm. The organic matter (OM) content of the sample is determined from organic carbon according to the following formula:

$$\% OM = 1.72 \times \% CO$$

With% C = (ml of excess 1N potassium dichromate * 0.004) / weight of substrate.

Mineral element concentrations

Phosphore content

The analysis is based on the solubilization of phosphorus in a solution of sodium bicarbonate at pH = 8.5 using 2.5g of soil. The phosphore concentration was measured at 580 nm wavelength with spectrophotometer (BioBASE).

Potassium, sodium and calcium content

Nutrient concentrations in soil were done using a Flame photometer (JENWAY®) after the extraction of 5 g of soil.

Statistical analysis

For all parameter, statistical analyses were performed by analysis of variance (ANOVA) using the SPSS 20 program. Mean separation was done using Duncan's test and the significance level of 5%.

III. Results and Discussion

pH and conductivity of sediments

Results presented no significant differences between sampling points (table 1). Nevertheless the pH increases slightly in the sediments N°6 and N°7 this can be explained by the agro-pastoral activity on the sites. This result is in accordance with findings of (Dbara and Lahmar, 2021) which affirmed that the pH increased with the use of treated waste water in irrigation. We cand deduce that socio-agricultural activity controls in part an environmental specificity which is reduced in the present work in sediment pH.

Concerning the EC measurements given important values in sediments samples N°6 and N°7 which correspond to cultivated terrace however others showed similar values. This is can be due to the excessive use of fertilizers compared to sediments near the wadi. Also, the increase in pH and electrical conductivity can interfere with the uptake of minerals by plants (Dbara and Mars, 2021). Previously, it was demonstrated that EC varied proportionally with the localization in relation to the course of the wadi (Lahmar et al., 2021).

Table1: Physical characteristics of sediments in different locations

	N°1	N°2	N°3	N°4	N°5	N°6	N°7
pH	7.67	7.63	7.56	7.78	7.68	7.92	7.93
EC (µs)	240	206.3	165	175	183.33	414.5	724.5

Chemical characteristics

Organic matter

Results showed significant differences between points (Fig..). The most important organic matter content was observed in sediment in the point N°4. This zone is a cultivated terrace which benefits from two contributions: wadi and terrace waters (Fig 5A.). Also, the sampling N°3 and N°5 recorded important values which exceed 4%. This zone is the closest to the talweg (Fig 5B). In an other hand, the sampling N°1 and N°2 which are very far from the wadi El Guelta showed low values that are considered as control. Equally, the sampling N°6 and N°7 presented similar values which can be explain by the depletion of sediment stock by crops (Fig 5C).

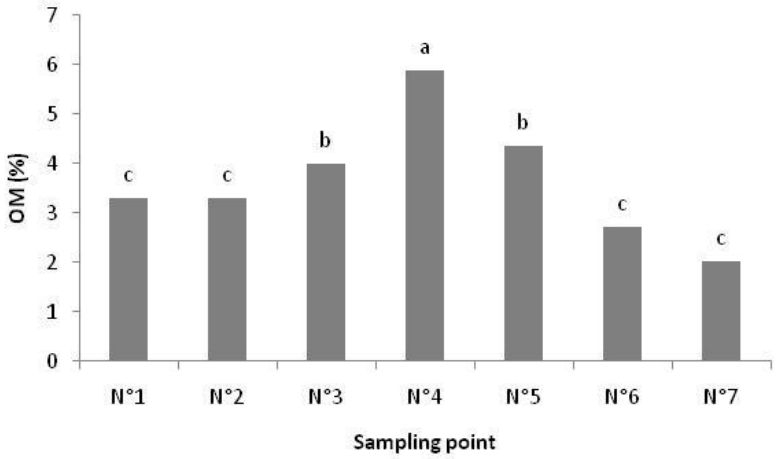

Figure n°4: Organic matter content (OM %) of the soil in different points.

Our results confirm them of Dbara and Lahmar (2021) which noted that irrigated soils with treated waste water improved this parameter. Also, in other studies it was affirmed that the cultivated area with treated waste water showed an increase of organic matter in soils (Dbara and Mars, 2021).

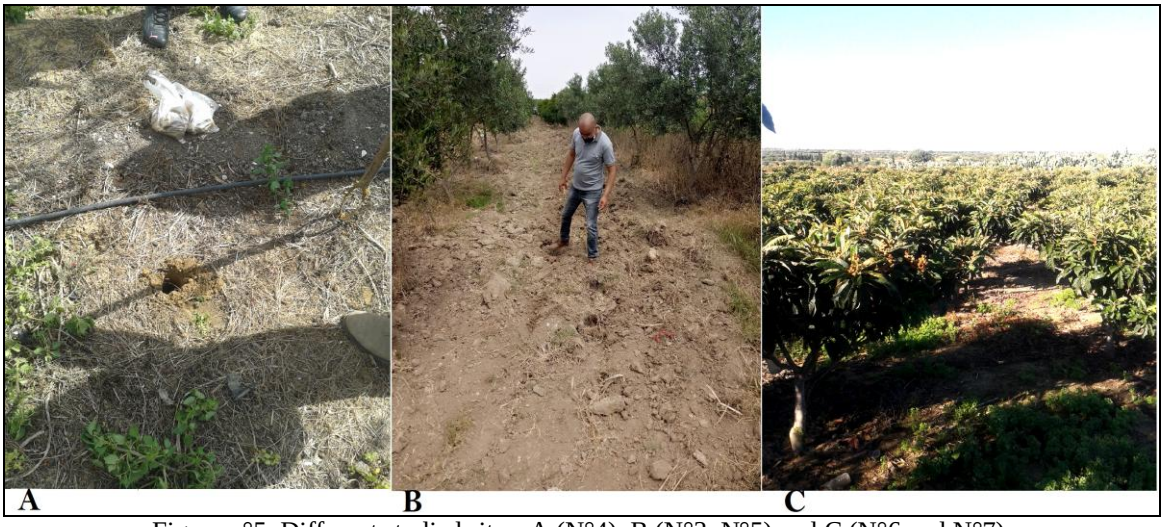

Figure n°5: Different studied sites: A (N°4), B (N°3, N°5) and C (N°6 and N°7).

Mineral elements concentration

The determination of mineral element concentration in sediments revealed significant differences (Table1). In fact, the main values of phosphore were observed in the sediments N°6 and N°7 respectively 0.13 and 0.14 comparatively to other points. As it was mentioned at the EC, the concentration of mineral elements in these cultivated terraces such as phosphore is important. Equally, the same observation was noted for potassium and an increase in sediments N°3 and N°5 was found. The waters loaded with mineral elements feed the sediments. But this is not the case for the calcium and sodium.

Table 2: Mineral elements contents in sediments: Phosphore (P), Potassium (K), Calcium (CA) and Sodium (Na).

	P (mg/kg)	**K (mg/Kg)**	**Ca (mg/Kg)**	**Na (mg/Kg)**
N°1	0.070	2.75	196.92	12.50
N°2	0.040	3.00	206.15	18.75
N°3	0.030	8.00	213.85	11.25
N°4	0.030	2.50	226.92	06.25
N°5	0.080	8.00	308.46	07.50
N°6	0.130	4.60	298.23	02.20
N°7	0.140	8.63	440.00	10.00

The results obtained emphasize the increase in these chemical traces and also prove that strong anthropization could explain this increase as well as the geomorphology and geology of the study area. The investigations of this experiment also revealed that the minor bed of the wadi G is the most affected.
The results obtained can be explained at least by the following three factors:

* **Pedological and geological**

The nature of the soil in the Ouardanine region (structure and texture) as mentioned above facilitates the release of some minerals allowing the catalyzing of the values obtained. The clay allows the release of sodium ions. In addition, limestone due to karstification is considered to be a factor releasing calcium ion. We can then deduce that apart from the stagnant water factor in the wadi el Guelta there is the geological and pedological factor which favors the chemical kinetics in the sediments of the study area.

* **Geomorphological**

The dome shapes of the study area can only increase the kinetic speed of the abundant waters feeding the wadi el guelta. This acceleration increases sediment inputs and promotes the upstream/ downstream accumulation of chemical material (Lahmar et al. 2021). The region is characterized by strong water erosion.

* **Agro-pastoral**

Agro-pastoral activity is intensive with the adoption of irrigation and fertilization. Moreover, the number of wells exceeds 460 wells in the Sahline-Ourdanine region (CRDA of Monastir, 2007) with an exploitation rate exceeding 84.4% and a water volume of 1.1 billion m^3. The control of the use of inputs is often difficult. The excess is transformed by running water in the bottom of the wadi.
The conjunction of these parameters can be presented by the following sketch (Fig 6). A synthetic diagram showing the role of each of the parameters in the composition of the sedimentary archives of the El Guelta wadi.

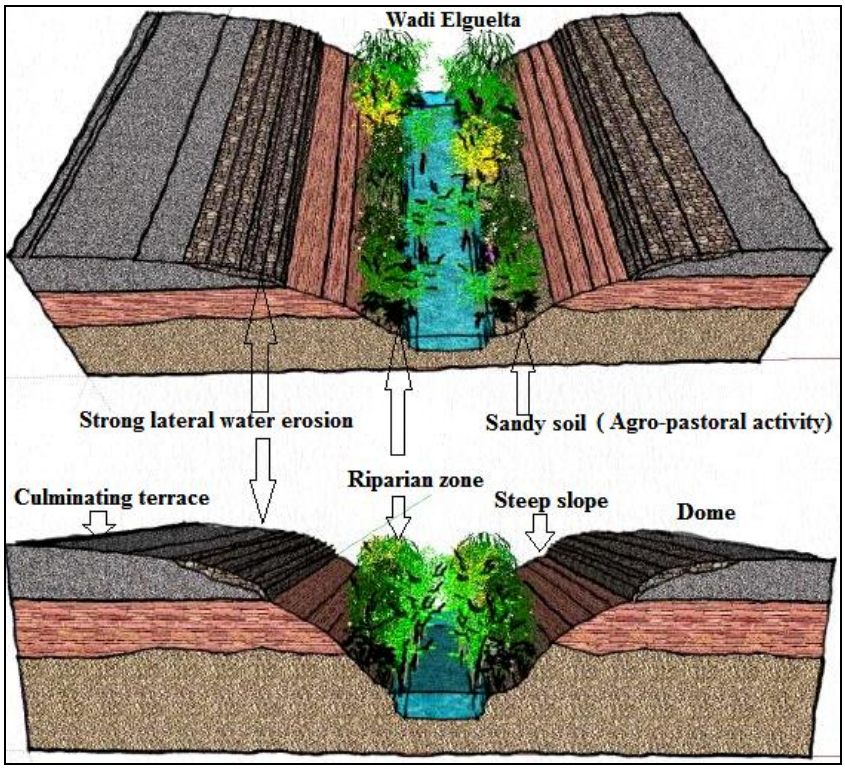

Figure n°6: The conjunction of differents parameters

Recommendations

Fight against invasive plants

The problem of the invasion of rivers by plants is gaining more and more importance in maintenance plans and this trend is likely to worsen in the coming decades (Boyer, 1998). The case of reeds in the wadi of El Guelta. The dynamism of this plant is very accelerated and can cause real mouths in the bottom of the wadi and feed the watercourse with debris of vegetation and consequently with organic matter (Fig 7).

Figure n°7: The invasion of vegetation in 'Wadi Elguelta'.

Define a management plan for bank afforestation and dead wood

It is proposed to carry out a detailed diagnosis, the definition of management objectives and the multi-year programming of the works within the framework of a management plan for the deforestation of the banks of the El Guelta wadi and the surrounding courses.

The detailed diagnosis corresponds to a reconnaissance of the land, which makes it possible to establish an inventory and already identify certain issues based on the type of occupation and the number of people around the wadi, the landscape or ecological potential.

The definition of the maintenance plan is also based on the choice of technical objectives that vary according to the different "sectors" of the watercourse and function of issues clearly identified among three themes: risks, uses and biological functioning (Boyer, 2004). The "sectors" combine various types of information, on the one hand localized issues (type of land use, uses, etc.), and on the other hand biological or physical data: such as the width of afforestation, risk of pulling and dragging of wood downstream, risk of obstruction of structures (Boyer and al, 2003).

IV. Conclusion

This work shows that socio-anthropogenic action affects the quality of the environment. The analysis of the sedimentary archive of the region of Ouerdanine reflected an image of strong anthropization and non-rational use of water resources. Geology and geomorphology have played an important role in increasing inputs of chemical facies in the bottom of the El Guelta wadi. To control the phenomenon and fight against the harmful consequences, an intervention plan was proposed in the form of recommendations. These allow nature to be preserved and restore the geomorphological shape of the stream.

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