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## Soil Erosion Analysis in the Oued Lahouir, Medjerda Basin, North-Eastern Part of Algeria

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### Abstract.

Soil erodibility is a key factor for soil estimation erosion through modelling techniques. Data from soil maps are often utilised to generate soil erodibility maps, for planning soil conservation measures. The purpose of the present study was to determine the erosion factor and predict soil losses due to water erosion in the Oued Lahouir basin situated in the north-eastern part of Algeria. Top soil samples were taken from a depth of 0-20 Cm of the 50 selected points. Field surveys, physico-chemical analyses and geostatistical processing, confirm the erodibility of certain soils in this region. These processes are likely to have a very negative impact on the Ain Dalia dam, by clogging its supplement from this river. The results of the soil analysis were interpolated using geostatistical methods ,ordinary Kriging (OK). The soil texture was clay, sandy clay and sandy clay loam. The organic matter content was estimated at 10.1%. The obtained erosionability indices indicate that most of the values are below 0.30. These relatively low index values show that the cause of erosion in the study area may not be due solely to soil properties, but could be the result of other factors such as the intensity and duration of rainfall. At this stage of the study, the soil erodibility map can be useful in designing techniques and building conservation structures that can minimise erosion in the catchment.

**Key words:** Erodibility, Geostatistical, Organic matter, Soil erosion, Oued Lahouir.

## 1. Introduction

Erosion has been shaping the earth's surface and man has been struggling with erosion to protect the soil from the aggressiveness of rain and runoff (Lowdermilk, 1989). It was noted that until the 1940s researchers discovered that the energy developed by falling raindrops was at the origin of soil surface disturbance, runoff and much of the erosion observed on cultivated land (splash effect) (Ellison, 1944).

Over time, scientific research has progressed in several areas, hence the relative effect of different factors which have modified erosion were quantified. Also, they have shown that slope steepness is more important than slope length, the influence of which is closely linked to the condition of the soil surface (in particular its roughness). It is now recognized that water erosion by rain on soil is a natural phenomenon that takes place in two stages; the detachment of particles and small aggregates by the impact of raindrops then the carryout of this soil downstream by runoff. This phenomenon is under the control of a series of factors known as erosion factors, which are rainfall, soil type, relief, cultivation practices and other land uses.

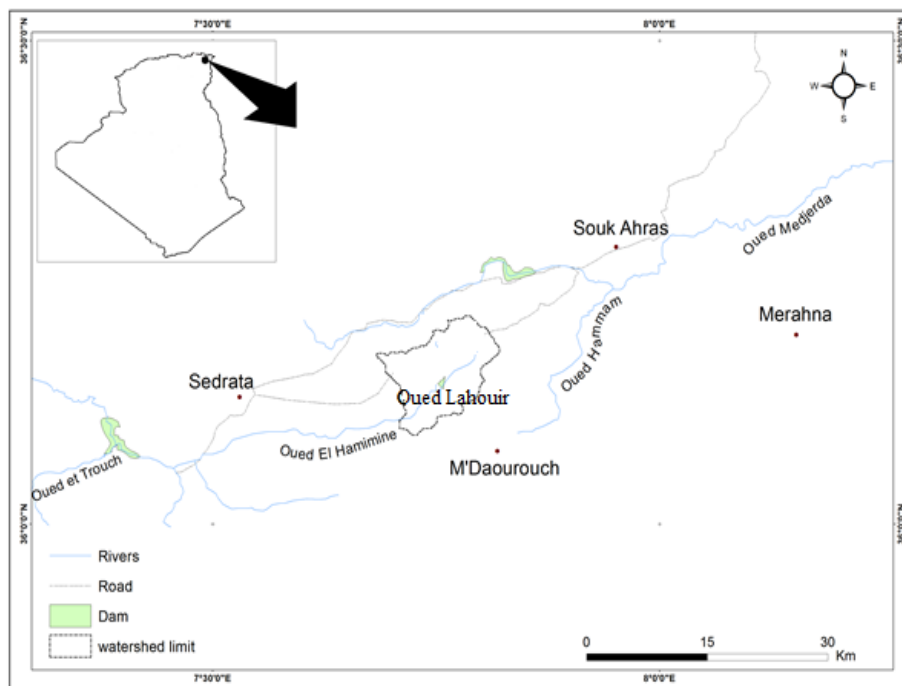
Soil productivity is the most critical resource for human food supply. However, due to population growth and the intensification of agricultural practices, the decline in this productive capacity and along with increased soil erosion rates, the phenomena has become a socio-economic challenge. As a result, improving erosion control management techniques, to better understand soil erosion dynamics and predict soil loss, have received increased attention (Veazy et al., 2011). Soil erosion varies over time and space, reflecting how easily soil can be displaced by surface runoff, rainfall splash or both. So, these characteristics are a key indicator of land degradation (Othmani et al., 2023).

Most studies rely on traditional sampling methods, calculating the K-factor for each soil type in the area (Weslati et al., 2023; Jodhani et al., 2023) or applying basic geostatistical techniques ordinary kriging (Ferreira et al., 2014; Lin et al., 2019) to create maps of these properties . The aim of this study was to determine the soil erosion factor in the Oued Lahouir basin and to explore geostatistically the spatial variability of certain soil properties in order to identify erosion-prone areas in a region subjected to high anthropogenic pressure in which agriculture plays a key role and to predict soil losses due to erosion. In this region, the nature of the rock,

climate, soil type and cultivation practices are factors that accentuate erosion processes. These can lead to siltation of the Ain Dalia dam.

## 2. Materials and Methods

The oued Lahour catchment area is located in the south-east of the Souk Ahras region in Algeria (36° 15' North Latitude 7°54' East Longitude), it has an extension of 86 km<sup>2</sup> (Fig. 1). The region is surrounded by *Pinus halepensis* forests. The climate is Mediterranean, the mean annual temperature and rainfall are 15°C and 322 mm, respectively during the last decade. The study region is classified as a semi-arid climate (Kottek et al., 2006), with autumn and winter being the wettest seasons, and summer being dry hot. The methodology used was to study the dependence of erodibility on soil properties (organic matter, texture, permeability and soil structure). The study was divided into three parts; field sampling, laboratory work and evaluation of the results.



**Figure 1.** Location of the study area.

The soil samples of the 50 points were georeferenced by GPS (UTM coordinate, WGS84), a description of the environment was made (visual recognition of vegetation, nature of the rock, land use) and a soil sample was taken at a depth of 0-20 Cm. In the laboratory the samples were prepared (drying and sieving) for the following physicochemical analyses: Granulometry

(Robinson pipette) (Beretta et al., 2014), hygroscopic humidity (oven drying) and organic matter content (LOI method) (Poot et al., 2009).

The 'K' factor expresses the vulnerability of the soil to erosion by rainfall. This factor depends on the physical and chemical properties of the soil (particle size, aggregation, structural stability, porosity, organic matter content, etc.). This factor was estimated from Wischmeier and Smith (1978). Resistance to water erosion is lower in shallow soils than in deeper soils (Ryan, 1982). Thus, when soils are shallow, they are quickly saturated by water after rainfall, runoff is accentuated and there is a downward movement of particles down the slope, even if the slope is shallow.

### **Statistical Analysis**

The data underwent standard analysis to obtain descriptive statistics, including the mean, minimum, maximum, median, variance, standard deviation (SD), coefficient of variation (CV), kurtosis and skewness for each parameter. Skewness, with values ranging from -1 to +1, is the most commonly used parameter to determine the normality of the data. For this initial analysis, the data's normality was assessed before applying geostatistical methods to create prediction maps. Additionally, a QQ plot test was conducted to further verify the normal distribution of each dataset.

Geostatistical methods use the stochastic theory of spatial correlation to make predictions at unsampled locations and assess the uncertainty of those predictions. Kriging, one of the most widely used interpolation techniques, estimates variable values across a continuous geographic area using a limited set of sampling data. This method requires a mathematical model to represent spatial covariance, typically expressed as a variogram (or semivariogram), which, in its parameterized form, serves as a fundamental tool in geostatistics. With these analytical results, maps were made to show the properties and the erodibility (K) expressed in percentage, using the ordinary Kriging method (Surfer© software).

## **3. Results and Discussion**

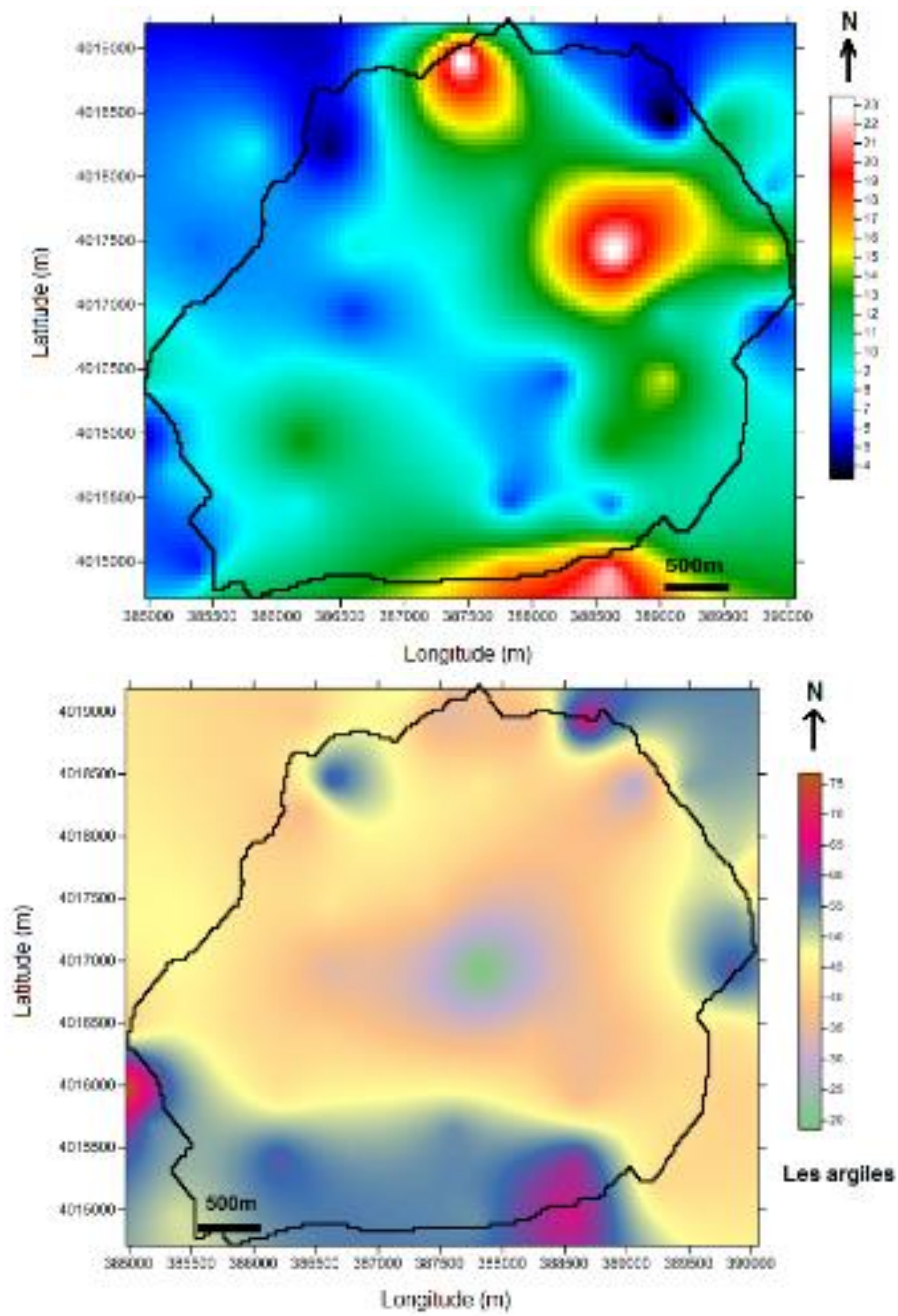
The dominant vegetation found in the Oued Lahouir sub-basin is mainly crops (cereal crops). This agricultural land is developed on slopes often exceeding 10%.

### **Statistical Analysis of Soil Properties and Soil Erodibility**

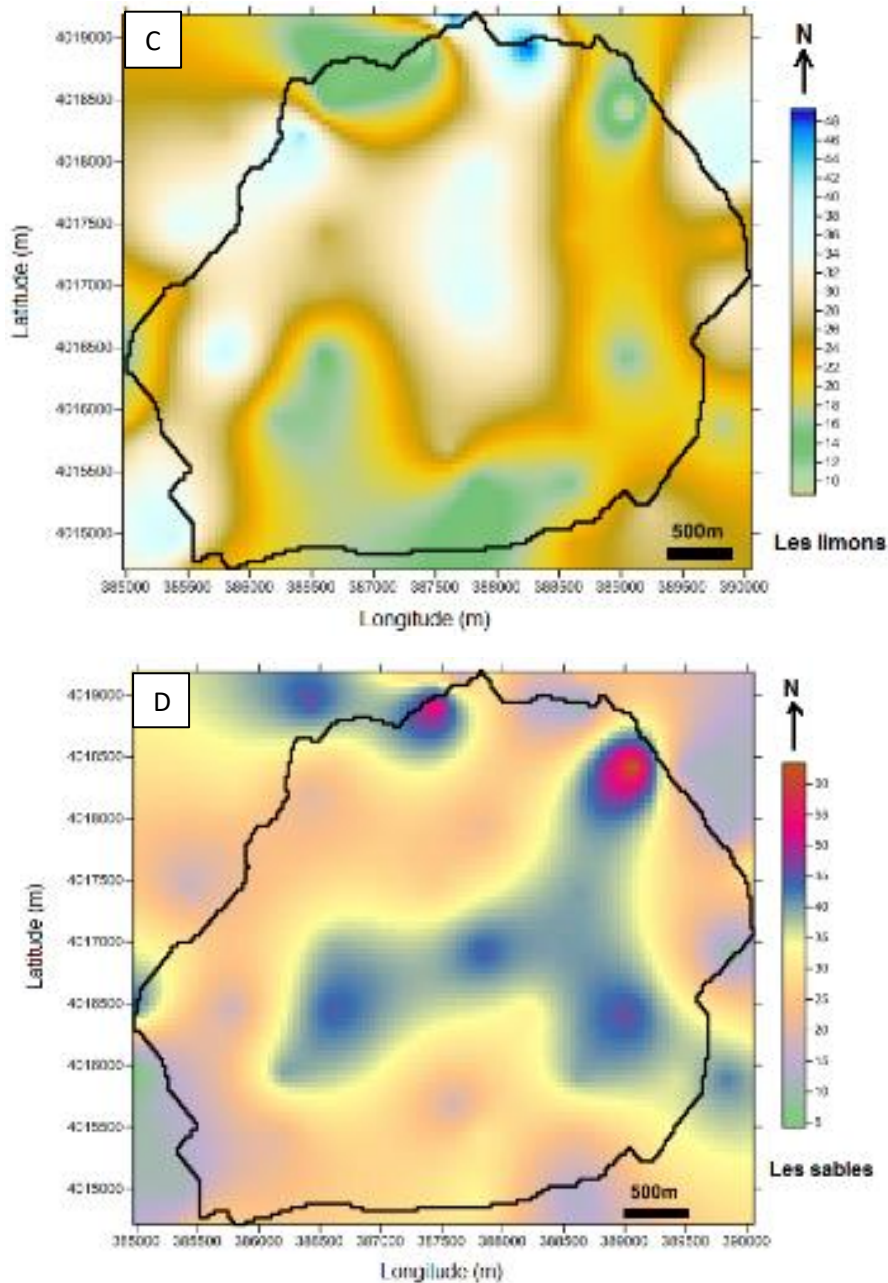
The statistical analyses of soil properties are presented in Table 1. The mean value of clay and silt are moderate with 46% (SD: 10.7) and 26.6% (SD: 10) respectively, while sand represented 28.1% (SD: 13.5). The organic matter content varied between (2.8% and 24.2%) and these are traduced as a map (**Fig.2**). For the moisture content (H%), values vary between 1.27% and 11.5% with a mean of 5.7% (SD: 2.6). The erodibility factor (K) shows lower variability, ranging from 0.11% to 0.33%, with a mean value of 0.17% (SD: 0.03) (**Fig. 3**). Skewness and kurtosis values indicate that most soil parameters follow a near-normal distribution, except for organic matter and the K factor, which are more positively skewed and exhibit higher kurtosis (**Fig.3**).

**Table 1.** Descriptive statistics of the soil parameters.

<b>Parameter</b>	<b>Clay (%)</b>	<b>Silt (%)</b>	<b>Sand (%)</b>	<b>H (%)</b>	<b>OM (%)</b>	<b>K (%)</b>
<i>Min</i>	17.8	7.6	3.38	1.27	2.8	0.11
<i>Max</i>	78	50.9	65.3	11.5	24.2	0.33
<i>M± SD</i>	46±10.7	26.6±10	28.1±13.5	5.7±2.6	10.1±4.8	0.17±0.03
<i>Skewness</i>	0.4	0.5	0.3	0.22	1.28	1.47
<i>Kurtosis</i>	1.1	-0.1	-0.04	-0.8	1.51	5.14



**Figure 2:** shows the distribution of organic matter and soil granulometric fractions using ordinary Kriging.

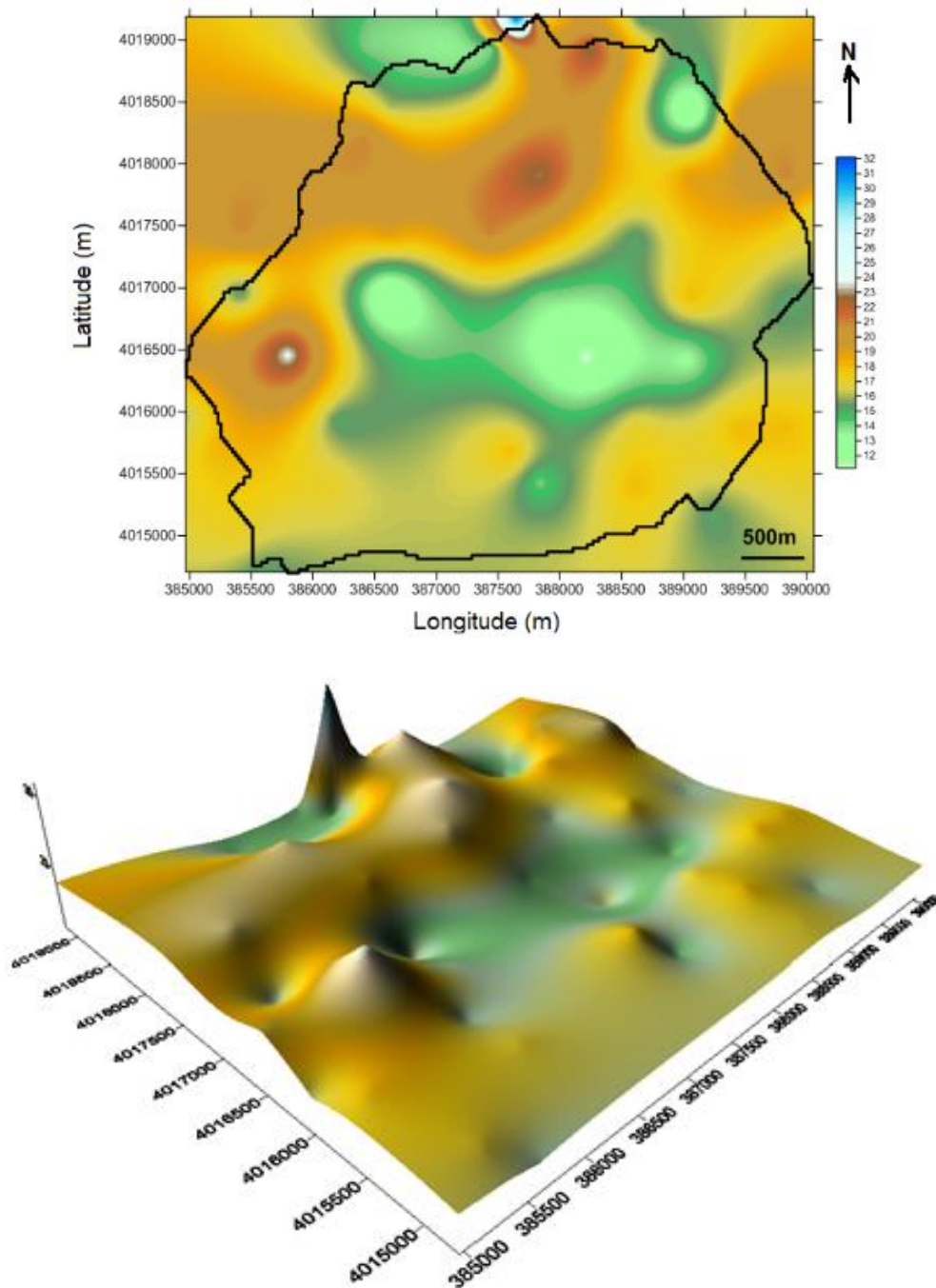


**Figure 3.** Maps showing (A) organic matter content, percentage of (B) clay, (C) silt and (D) sand in the Oued Lahour sub-basin.

The kriging method was used to interpolate and estimate the K-factor value of the unknown points based on the value of the known K samples from the calculation of this value for each sampled point.

It could be observed that areas with high K-factor values ( $K > 19\%$ ) are distributed on loamy, loamy-limestone surfaces, showing numerous erosion marks and soil structural instability (visual analysis). In these areas, scattered crops and pastures with often quite steep slopes are developed. Among others, the large areas of clay and loamy soils, which exceed 40% for the

former and vary between 28 and 35% for the latter. They are characterised by a sensitivity to erosion, with numerous areas of great instability with landslides, gullies and ravines (**Fig. 4**).



**Figure 4.** Map showing the variation of the K-factor (%) and its 3D representation.

Regardless of most of the soils analyzed exhibited low levels of organic matter, this parameter alone is not sufficient to determine the overall condition of the soil in terms of healthy management practices. Organic matter influences many soil properties, including soil

erodibility, which is a critical factor concerning soil loss (Othmani et al., 2023). Therefore, it is essential to implement soil conservation practices that focus on maintaining organic matter content within the soil profile. This comprehensive approach can significantly contribute to reducing soil loss and mitigating the effects of climate change.

#### 4. Conclusions

The sensitivity of the catchment depends to a large extent on the environmental conditions. The survey carried out in this region has revealed a significant erosional activity dominated by water erosion causing runoff and gullies and materialised by large-scale landslides. Evaluation of the physico-chemical properties of the soils (texture, organic matter content, electrical conductivity and moisture) in this region reveals that the soils have a high erodibility. The combination of laboratory results and field survey using the geostatistical tool has enabled us to draw up the various explanatory maps revealing the magnitude of this phenomenon. The material carried downstream will participate in the clogging of the Ain Dalia dam.

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