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# Spatial pattern of the eutrophication expression: A case of lake Oubeira (El-kala National Park, North-east Algeria)

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**ABSTRACT**

Oubeira lake is a freshwater body that is disturbed by both natural and anthropogenic factors leading to significant trophic fluxes. Spatial analysis is a promising approach in the field of ecosystem monitoring and management. At the landscape level, these disturbances are reflected by the spatial organization that characterizes the extent of the eutrophication phenomenon. The analysis of the patches that structure the spatial expression of the eutrophication phenomenon has enabled us to evaluate the degree of propagation of alterations and the intensity of the mechanisms that generate the ecosystem service of purification and depollution. The use of spatially specific methods for analysis and sampling of data has increased the level of expression of results. The analysis of the main spatial components (Mulispati-ACP) has proven to be very effective in providing a spatial typology based on the spatial dependency expressed by Moran's statistics. The results obtained from this process, combining a multivariate spatial analysis method and geostatistical. The generated model was useful to identify a gradient organization. The spatial pattern arrangement revealed the functional aspect related to the intensity of eco-biological and hydrological process

***Key words:*** *Fresh-water, Eutrophication, Spatial-modeling, Multispati-PCA-Geostatistics-Mapping- Kriging*

## Introduction

Northeast Algeria is home to a large number of sites that are part of the Eastern Numidia wetland complex. Oubeira, an endorheic freshwater lake, is an integral reserve located in the El-Kala National Park (Chalabi, 1990). Its richness and diversity ensure the life cycle of several biological forms and guarantee the correct functioning of the trophic cycle through multiple services. Unfortunately, the progressive urbanization together with unconventional agricultural practices have worsened the problem of sewage and pollution, both known to be as growing risks to its functioning and stability.

The wetlands are dynamic systems that are subject to significant changes (filling, vegetation closure, drying, etc.) due to natural or anthropogenic disturbances. The management of these ecosystems requires a good knowledge of the mechanisms that contribute to the effective functioning of the services related to its balance as well as its resilience (Swenson, 2014).

The ecosystem management approach is a field of application that aims to identify organizational levels, stable states, interactions between parties and factors of balance and imbalance that characterize the functioning of an ecosystem. This management mode aims to restore functioning by reestablishing the normal status of all ecosystem functions and services (Arpin and Cosson, 2018; Gownaris *et al.,* 2018; Schröter *et al.,* 2018). The diagnosis must cover a global scale offering a wide perspective that allows the understanding of the functional level

The analysis of spatial models is of primary interest since forces with spatial components do structure most ecological phenomena. Ecological processes can cause reactions with recognizable spatial patterns, which can be analyzed (Legendre *et al.,* 2002; Liebhold and Gurevitch, 2002). The monitoring of dynamics in the field of spatial ecology is based on three concepts: the patch (spot or pattern), disturbance and ecological succession. Each pattern constitutes a functional ecological unit, more or less homogeneous, stable or isolated, which differs from those surrounding it, for a certain temporal and eco-landscape scale (Legendre and Fortin, 1989; Legendre and Legendre, 2012). The analysis of spatial structures has become possible due to the progress in the field of GIS (Geographic Information System) and the generalization of the concepts of geostatistics in the field of ecology. The benefits of GIS tools have made remarkable progress in the field of cartography (Swiderski *et al.,* 2016). The map has become an accurate means of analysis, modelling and diagnosis for management and decision-making (Dale *et al.,* 2002; Dray *et al.,* 2008). Based on these theoretical facts and in other to verify the hypothesis of any presence of a spatial structure, we developed a strategy based on spatial sampling followed by a statistical analysis process combining a multivariate spatial method (Multispati-PCA) that allows the integration of spatial proximities into multidimensional analysis (Dale *et al.,* 2002; Schneider *et al.,* 2016; Giannini *et al.,* 2018; Saby 2009) and geostatistical methods.

The results are promising since they confirm that integrating space into the analysis of ecological data is a good approach in the domain of ecosystem management.

## Materials and Methods

### Presentation of the study site

Oubeira Lake is located in the Northeastern zone of Algeria between Latitude 36° 50' North and Longitude 8° 23' East at an altitude of 25 m (Fig. 1). It is a permanent freshwater endorheic lake, with a surface area of 2200 ha. It lies in the central part of the National Park of El-Kala with the status of a Ramsar site since 1983.

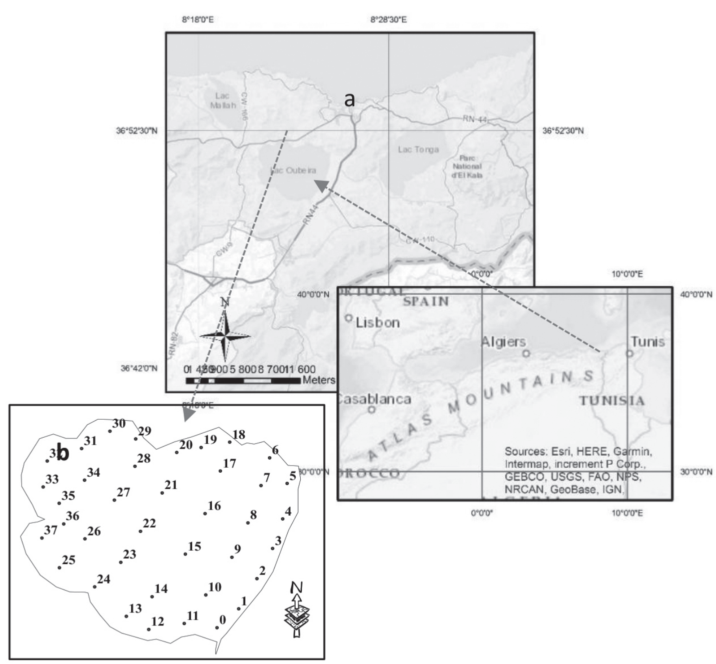


**Fig. 1.** Location of the study site (a) and sampling protocol (b)

**Sampling design and methods for the determination of physicochemical parameters**

Sampling is based on a Protocol involving a random sowing of 38 stations, the minimum required for modelling (Legendre and Legendre 2012; Dale *et al.* 2002). Each station was subjected to in situ measurements of physico-chemical parameters using a field multi-parameter (Harriba U50). To assess the trophic level of lake water, the nutrients ($NO_3$, $NO_2$ $PO_4$, $NH_4$ and $SiO_2$) were measured in the laboratory according to the principle of complexing and photometric determination methods (Rodier *et al.*, 2016). The chlorophyll-a level was assessed following Lorenzen (1967) procedure and spectrophotometric determination (Rodier *et al.*, 2016).

**Statistical analysis**

Several statistical methodological approaches have been used:

The unidimensional description of the data in order to quantify and characterize the results of physico-chemical and biological analyses so as to compare them to the references' values.

- The Variance analysis for repeated data. This choice is justified by the pairing cases that are recorded during each season.
- The multidimensional analysis of the data of a mean-season matrix via the multivariate spatial analysis due to the regional characteristics of the variables used. To do so, the spatial principal component analysis (Multiparti-PCA) involving the use of a weighting (distance matrix generated by neighborhood relations) as a constraint (Thioulouse *et al.*, 2018; Córdoba *et al.*, 2012) has been used.

The weighting optimizes the expression of the spatial typology. The Multispati-PCA analysis provides components by maximizing the autocorrelation calculated based on the Moran Autocorrelation Index (MI) (Dray and Jombart, 2011) and generates cartographerable components that are used to build up the spatial organization model of eutrophication. The coordinates of the most spatialized components were used to perform the following geostatistical analyses:

- Moran's I index and the Monte-Carlo permutation test (Legendre and Legendre, 2012) were used to measure and test the presence of a spatial structure.
- Definition of the theoretical model that fits the empirical model according to an iterative process using variographic analysis and cross-validation.
- Generalization of the expression of the geographical model by interpolation according to the principle of ordinary kriging (Borcard *et al.*, 2011; Legendre and Legendre, 2012; Legendre and Frotin, 1989).

The implementation of the different statistical methods required the use of the R.v.3.3.3.1 software and its packages (ade4, sp, rgdal, spdep, maptools) (R Core Team, 2013) as well as the ArcGIS.10.2 software.

## Results

**Descriptive and inferencial Statistics**

Table 1 summarizes the eutrophication and pollution status shown through the results of descriptive and inference statistics of the sampled variables. The following characteristics are derived from these results:

The physicochemical and biological parameters show significant seasonal fluctuations that define several surface water quality degradation in relation to the parameters that affect the trophic level of 7 the lake, namely nitrates (22.07 ± 4.384 mg/L), phosphates (1.312 ±0.486 mg/L) and turbidity (126.64 ±11.72 NTU). This eutrophication state, according to the assessment grids recommended by the control authorities (Table 2) is a consequence of multiple natural and anthropogenic factors.

The variations in the temperature water surface (20.67 ± 2.577 °C) represents a thermal regime that is favorable to the development of biological processes (Scheffer 2004). The oxidizing power (198.13 ±6.225mV), good oxygenation (7.165 ± 0.61 mg/L) and dominant alkalinity, as well as the nutrients, constitute a favorable environment for the development of phytoplankton blooms. The chlorophyll-(a) values (75.87 ±12.07 µg/L) reflect the importance of algal blooms that affect the high level of eutrophication characterizing the water body according to the OECD (1982) classification.

**Expression pattern of the spatial structure of the eutrophication**

The following steps has been followed to build up the pattern:

1. Determination of the mean matrix of seasonal variations

**Table 1.** Descriptive and inferential statistics relating to physicochemical and biological parameters

| Parameters | TempC° | pH | Eh (mV) | Ce (mS/cm) | Turb (NTU) | OD (mg/l) | STD (g/L) |
|---|---|---|---|---|---|---|---|
| N | 4X38 | 4X38 | 4X38 | 4X38 | 4X38 | 4X38 | 4X38 |
| M G | 20.67 | 8.59 | 198.13 | 0.464 | 126.64 | 7.165 | 0.299 |
| F-Pr | 252-0.00 hs | 46.08-0.00 hs | 456-0.00 hs | 2661-0.00 hs | 129.5-0.00 hs | 252.52-0.00 hs | 3758-0.00 hs |
| Me | 19.1 | 8.64 | 197 | 0.457 | 121 | 7.49 | 0.297 |
| Min | 11.12 | 7.71 | 115 | 0.364 | 65.5 | 3 | 0.243 |
| Max | 33.41 | 9.12 | 249 | 0.549 | 236 | 10.81 | 0.35 |
| CV | 37.92 | 3.93 | 9.56 | 13.57 | 28.16 | 25.92 | 12.88 |

| Parameters | $NO_3$ (mg/L) | $NO_2$ (mg/L) | $PO_4$ (mg/L) | $NH_4$ (mg/L) | $SiO_2$ (mg/L) | Chlr-a µg/L |
|---|---|---|---|---|---|---|
| N | 4 x 38 | 4X38 | 4X38 | 4X38 | 4X38 | 4X38 |
| M G | 22.07 | 0.112 | 1.312 | 0.385 | 2.247 | 75.87 |
| F-Pr | 25 –0.00hs | 46.15-0.00hs | 95.91-0.00hs | 7.78-0.00hs | 55.15-0.00hs | 36.77-0.00hs |
| Me | 18.92 | 0.0987 | 0.46 | 0.21 | 1.535 | 72.4 |
| Min | 2 | 0.03 | 0.01 | 0.05 | 0.02 | 10.5 |
| Max | 63.6 | 0.36 | 5.4 | 3 | 6.4 | 188.6 |
| CV | 60.44 | 69.2 | 112.89 | 123.43 | 77.17 | 48.42 |

Legend: N : sampling effort MG : Global average (spatiotemporal average) - F: Fisher statistic for ANOVArep - Pr : Probability test- hs : highly significant - Me: Median-Min: Minimum-Max: Maximum –CV: coefficient of variation- Eh: Redox potential - Ce: Electrical Conductivity -Turb :Turbidity – OD : dissolved oxygen – STD : Solid total dissolved-Chlr-a : chlorophylle-a

2. The realization of the Multispati-PCA and the determination of the two most significant components
3. The computation of the Moran index and its test to verify the state of expression of the spatial structure of the first two components
4. The Variographic analysis and cross-validation test for the selection of the Model
5. The Interpolation according to the principle of ordinary kriging and mapping of the expression of eutrophication

**Multi-spati-PCA results**

Multispati-PCA is a spatially constrained ordination whose objectives are to summarize spatial structures. The interpretation is strongly oriented towards the interpretation of autocorrelation (Thioulouse *et al.,* 2018; Dray *et al.,* 2006) and based on the same steps as that of a conventional PCA.

Based on the results of figure 1 and considering the Moran autocorrelation values of the first component (IM: 0.75) and the third component (IM: 0.50) it appears obvious to retain the layout (CS1xCS2) in

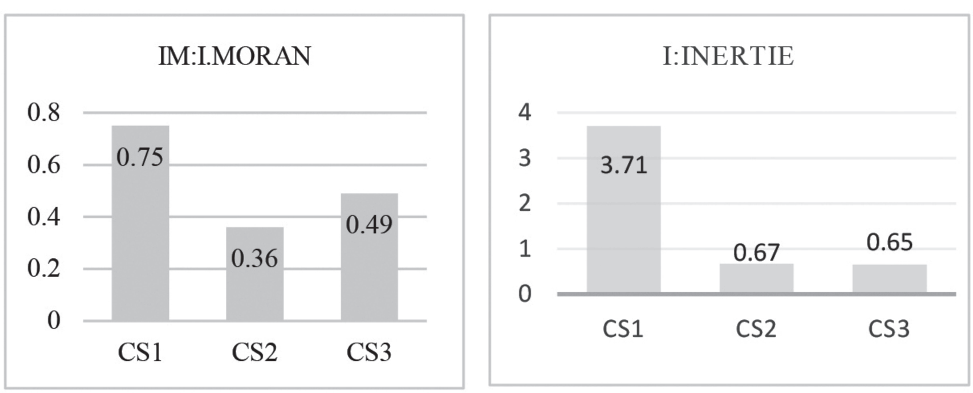


**Fig. 2.** Histogram of inertia values (left) and Moran Autocorrelation Index values (right) of the three principal components

order to describe the spatial structure. Its variation represents 41% of the total variation whose ide 38% and 10% are provided by the first and the third component respectively.

**a- Plan CS1xCS3 (variables)**

The ("CS1 x CS3") variable layout (Fig. 5) shows a double structuring of the initial variables distributed over the two selected axes. The first component (CS1) identifies a combination that opposes two groups of variables identified on the score recorded (Fig. 3).

- The first group (G1) combines all variables (CE-TDS-EH-$PO_4$-$NO_3$) that express a gradient of pollution and eutrophication. This combination represents an oxidative medium with a high-suspended matter content that allow the occurrence of the nitrification process (Fig. 3).

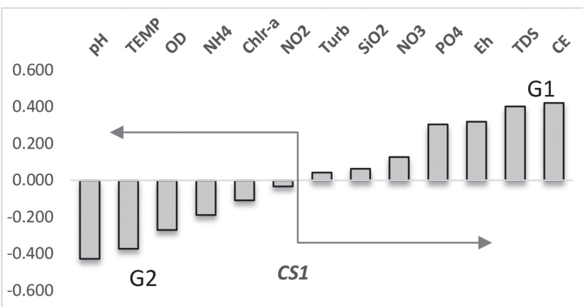


**Fig. 3.** Histogram of variable contributions to the expression of the CS1 axis gradient

The second group, however, (G2), composed of variables (Temp, pH, OD, Chlr-a) indicate the expression of biological processes related to physiological activities of respiration and photosynthesis. The alkaline tendency characterizing the expression of this gradient is the consequence of a photosynthetic activity that consumes $CO_2$ and affects the calco-carbonic balance.

The CS3 component expresses a combination that differentiates two groups of variables. The first group (G3) of variables (Turb-OD-Chlr-a-$NH_4$) indicates the transparency gradient expresses by both the turbidity and chlorophyll-a variables and the second (G4) expresses a gradient related to the SiO2 concentration (Fig. 4).

**Plan CS1xCS3 (stations)**

The factorial design CS1xCS3 stations (Fig. 5a) describes a spatial typology. The point cloud (stations)

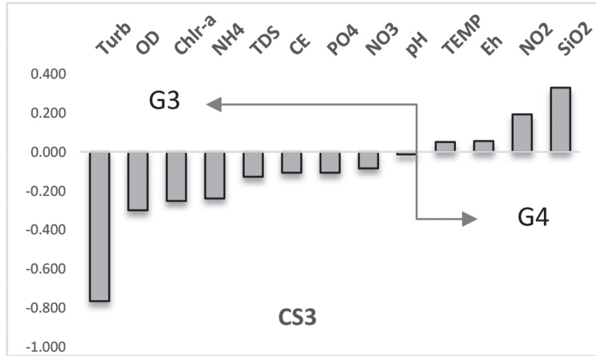


**Fig. 4.** Histogram of variable contributions to the expression of the CS3 axis gradient

illustrates a Gutmann effect reflecting the gradient expression

The CS1 component differentiates between the stations that distinguish the West-North-West zone represented by the stations (38-36-31-29-26…etc.) and the East-South-East zone represented by the stations (1-2-8-10… etc.) according to the gradient identified on the CS1xCS3 plane (variables) as an eutrophication/pollution gradient.

The CS3 component separates the Southeast and South-West stations (represented by stations 1-13-38- 15 ...etc.) from the Central and Northeast stations (Fig.5) according to the gradient on the map CS1xCS3 (variable) (Fig. 5b) defined as the water transparency gradient.

Multispati-PCA provides mapable components. This helped with the investigation of the eutrophication expression model based on the scores of the two station components CS1 and CS3.

**Eutrophication modeling and mapping**

The development of the spatial model is the result of a phase of validation of the geo-statistical assumption of dependence (stationarity) and a phase of extrapolation of the spatial expression as determined by stochastic interpolation.

**Identification of the spatial structure**

The Moran Index with its highly significant permutation test shows the presence of an important spatial structure in the expression of the chosen components. This is proved by the linear fitting (the component score is dependent on spatial distance) of which the slope is the Moran's statistic (Fig.6), strengthening the significance of the spatial structure of both the CS1 and CS3 components.

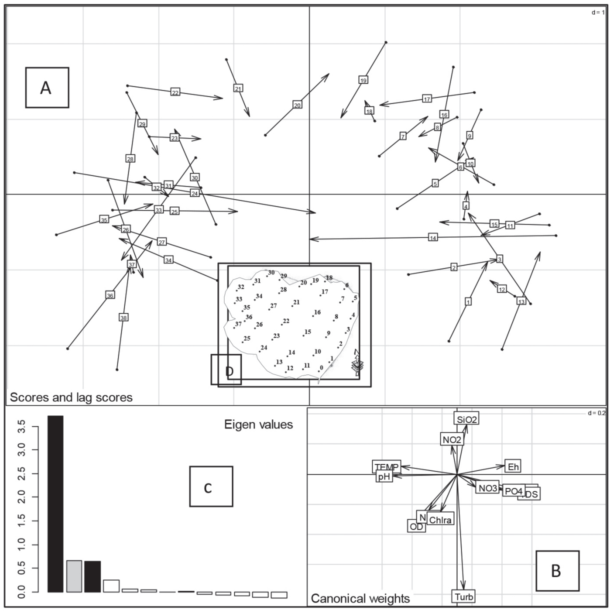


**Fig. 5.** Results of the Multispati-ACP. Fig. 5a spatial typology and station projection on the CS1xCS3 plane. Fig. 5b Structure of the initial variables that define the gradients of the two selected components. Fig. 5c Histogram of the contribution values of the components to the expression of the CS1xCS3 plane. Fig. 5d Graphical representation of neighbourhood relations and weighting between stations

## Variographic analysis

Its objective is to study the spatial structure of the data (CS1 and CS3 component scores) in for comparison with theoretical models. The method of choice is the semi-variogram, as it describes the evolution of the dependency measured by the semi-variance.

## Cross-validation and experimental variogram

Used to evaluate the accuracy of an interpolation model according to a process that produces pairs of predicted (predicted) and known (practical) values that can be compared to select the predictive variogram.

The errors due to statistics are used to estimate the quality of the estimates associated with the variogram model. The results are summarized in Mean and Mean Square errors. A accepted model is effective if the residual (error) criteria are close to 0 (Cardenas and Malherbe, 2003).

Table 2 summarizes results on the quality and precision of adjustment between the empirical model and the theoretical models chosen:

### a. The best theoretical model of adjustment to the empiric model CS1

Comparison results against CS1 indicate that:

- The average error and the standardized average error (Average bias) give a slightly higher advantage to the spherical model (value close to zero) compared to the other two models
- The standardized root mean square error and root mean square error (Adequacy Criterion) show the correct fit of the CS1 values to the spherical and circular model (value close to 1) in comparison to the Gaussian model.

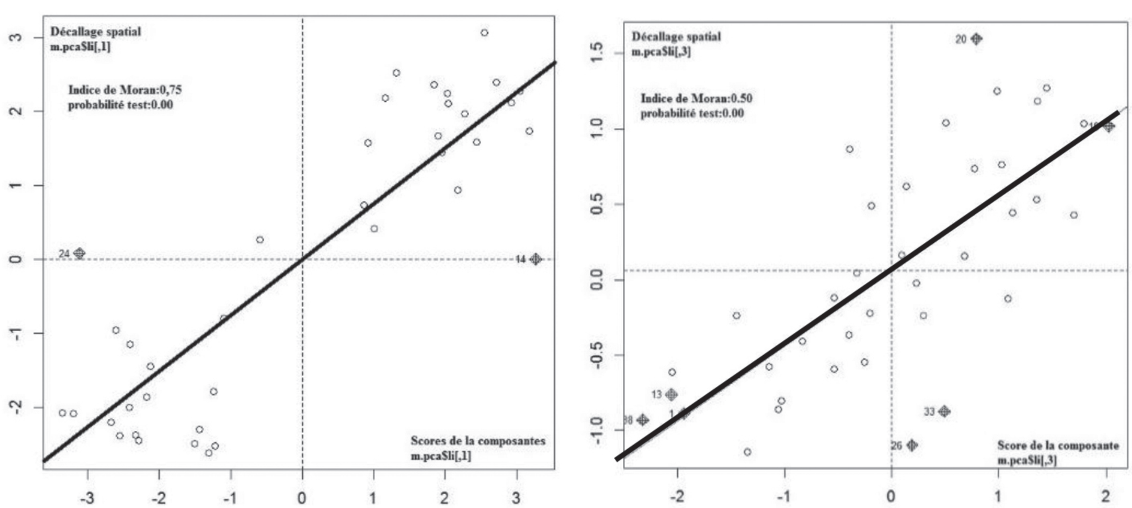


**Fig. 6.** Scatter diagram for the Moran index. Adjustment line representing the dependence of the scores of the components (CS1, CS3) to the spatial variation step.

**Table 2.** Cross-validation process results.

| Composantes | Critère d'ajustement | Circular | Spheric | Gaussien |
|---|---|---|---|---|
| CS1 | Mean error | 0.007 | 0.006 | -0.019 |
| | Quadratic mean error | 0.984 | 0.983 | 1.168 |
| | Standardized mean error | 0.005 | 0.004 | -0.197 |
| CS3 | Mean error | 0.01 | 0.007 | 0.004 |
| | Quadratic mean error | 0.733 | 0.74 | 0.712 |
| | Standardized mean error | 0.021 | 0.016 | 0.01 |

**b- The best theoretical model of adjustment to the empiric model CS3**

The comparison results against CS3 show that:

- The three models have low residuals and a good fit. The mean error values are similar and differentiate very slightly between the models.
- The values of the criteria root mean square error and standardized root mean square error are close to one (1) and reflect a good fit between the empirical model and the theoretical model retained. These criteria also make little difference between empirical models.

Giving that the cross-validation process is slightly advantageous to the spherical model, this result was taken into account to do the variographic analyses of both CS1 and CS3 components. The spherical model, one of the most commonly models used, reflects a gradual decline in spatial autocorrelation (equivalent to an increase in semi-variance) to a certain distance, beyond which this autocorrelation disappears (zero).

The semi-variogram of CS1 component (Fig. 7a) is characterized by a range that defines the dependency limit at 3000 m and a plateau of 5.25 corresponding to the variability level of the model. The CS3 semi-variogram (Fig. 7b) describe a range that limits this dependency to 2500 m and a plateau variability of 1.40. The absence of the nugget effect in both cases suggests (shows/indicates/proves) that the scale of observation used is appropriate for the type of the spatial structure of the variable studied. This also indicates the absence of bias in the sampling effort (procedure).

The step values distinguish two levels of structural variability. The level of the CS1 component expresses a degree of local variability and certifies (insures) that the dynamic of the studied-variable (eutrophication) is generated from hot spots. The result reflects the field reality since eutrophication is an enrichment of the lake due to effluents.. The threshold of the CS3 component characterizes a less important type variation accepted as water clarity. The Turbidity and Chlr-variables, which structure the expression of the CS3 component, have a spatial dynamic that tend to generalize their expression.

**Maps for predicting the expression of components**

The map based on the data (scores) of the first component (CS1) reflects the organization characterizing the expression of the eutrophication gradient (Fig.8). There is a zonal disparity opposing the East-South-East and West-North-West areas along a longitudinal gradient. The West-North-West part is characterized by clear patterns that reflect low eutrophication levels, while the East-South-East part is characterized by darker patterns expressing more intense eutrophication and pollution levels.

The CS3 component value prediction map (Fig. 9) distinguishes the Northeast zone and its central ex-

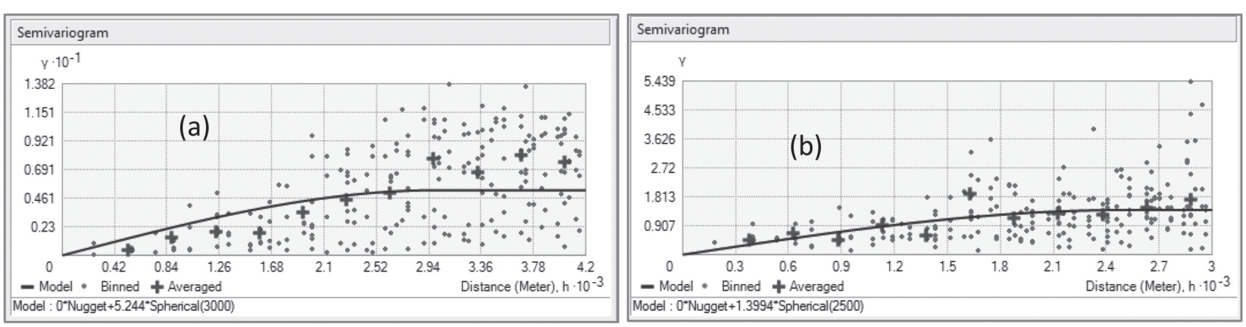


**Fig. 7.** Semi-variogram of the structuring model of both the CS1 (7a) and CS3 (7b) components

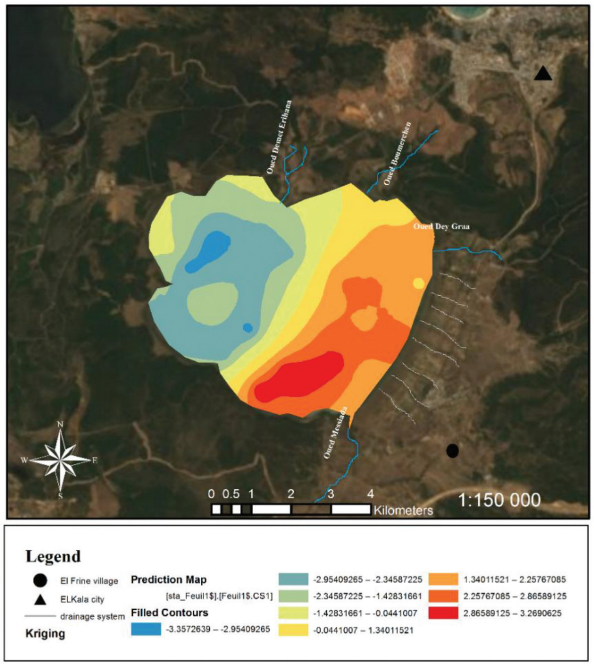


**Fig. 8.** Prediction map of the CS1 component scores representing the expression model of eutrophication

tension from the South and South-West zones as to the transparency gradient. The patterns characterizing it progress centripetally with central fringes of low level of transparency facing fringes located on coastal areas of low depth classes. The proximity of the effluents and the watershed of the Northwest Zone favors this situation.

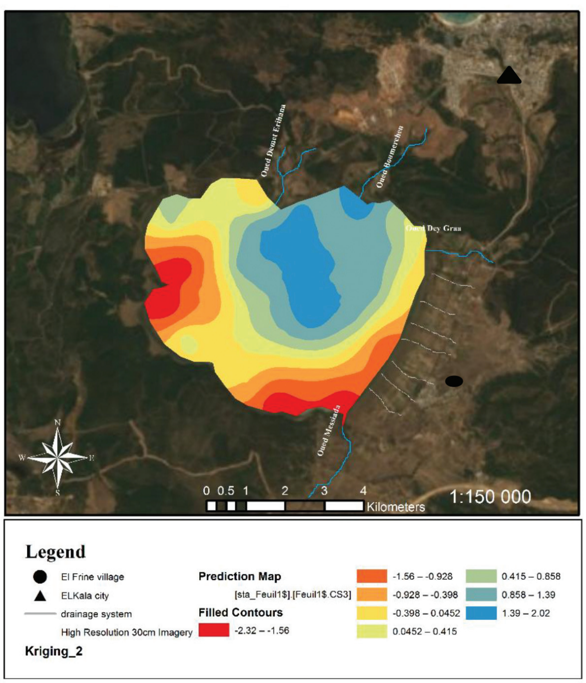


**Fig. 9.** Prediction map of the CS3 component scores representing the expression model of eutrophication

## Discussion

The fluctuations in the physico-chemical parameters levels of the lake's surface water are related to multiple factors (climatic, hydrological and anthropogenic) that determine the intensity of the eutrophication patterns dominating the landscape expression of this ecosystem:

- The proximity of the sea, the existence of lacustrine areas and the absence of orographic barriers generate a Mediterranean-type rainfall with a dry summer and a rainy stormy winter (Bolle 2003 ; Seltzer, 1936). As a consequence, groundwater levels are greatly affected which in turn affects the persistence as well as the functioning of lentic ecosystems (Alvarez-Cobelas *et al.,* 2005). A weak rainfall would affect the water level variation of low depth lakes. Lasting drought periods would increase salinity and conductivity, improving internal nutrient recycling and allowing eutrophication and proliferation of toxic microalgae (Beklioglu *et al.,* 2007). Lake Oubeira is located in the center part of a low height watershed with a moderate topography and low incisions characterized by a low erosion and torrentiality (Messerer, 1999). Four principal effluents drain the lake basin. Permanent flows are important during the wet season and but don't cause a complete dry out of the lake decrease during summer (PNEK, 2011). Messida is one of the principal rivers that operate as an effluent (outlet) during the low water period and as an affluent during winter when River "El-Kebir" is flooded . Other affluent such as "Dey graa" and "Dement Rihana" rivers effective during winter and are barely active during the summer. This has a great impact on the lake hydrology (Karapinar, 2005). The water layer, resulting from a positive water balance, is distributed over low depths levels. The ratio between the volume and the surface lead to low class depths in lake "Oubeira". The slopes of the south and east river banks are relatively acute but those of the western ones, are of a low inclination (Messerer, 1999). These different hydro-morphological characteristics are what caused the endoreism that characterizes this body of water and which allow a weak renewal and long sedentary state of water. As a result, sedimentation is active and favors the accumulation of a large layer of vase estimated at 30.21Hm$^3$ spread over an average depth of 1.32m (Maximum 2.50m) (PNEK, 2011). This large volume provides an important supply of nutrients and solids that maintain the eutrophication process. The trophic status of the lake is mainly linked to both nitrate and phosphate elements concentrations. The low depth classes that dominate lake bathymetry, water regime (organization) and morphology of the basin and watershed increase trophic level fluctuations (Talling, 2001; Noges *et al.,* 2003). Summer aridity conditions in Mediterranean regions lower water levels and increased stagnation time promotes longer water-sediment contact that ensures continuous nutrient release (Quintana *et al.,* 1998; Romo *et al.,* 2005). The dominants winds induce wave movement that ensures drift and resuspension of phosphate (Shen *et al.,* 2013; Bonnet, 1998; Bertrin *et al.,* 2011; Stephen *et al.,* 2003).

The seasonal fluctuations of nitrate concentrations in the conditions of Mediterranean shallow lakes are related to the rhythm of biological activities. The physiological phenomenon of the growth and the development of the biomass of primary producers (macro and micro flora) regulate the flow of nitrogen, generally leading to its significant decrease during spring (Shen *et al.,* 2013; Jeppesen *et al.,* 1998; Romero *et al.,* 2002). Nevertheless, this decrease is immediately (counter balanced) the activity of the cyanobacteria group, which have the ability to fix atmospheric nitrogen (Vollenweider, 1970). The spatial organization of eutrophication reflects a functional aspect. The distribution and arrangement of patterns characterizing the landscape expression of eutrophication reflect the intensity of the processes that define the ecosystem service. The spherical type model characterizes the spatial dynamics of eutrophication in Oubeira lake and shows the intensity of eutrophication phenomena within the banks, which tend to decrease as they progress towards the center. This is in accordance with the type of belt organization that generally characterizes the ecological zoning of lentic environments. The model as defined from the CS1 component calls back for an upstream-downstream dynamic type whose ends contrast the levels of pollution and eutrophication. Several processes are at the origin of this organization. The eastern and southeastern parts of the reservoir, due to its location, are supplied with water from a large number of affluent. During high water, these rivers carry important flows of organic and inorganic matter. On the other side, the Western and Northwestern zones are less exposed to external inputs. A large lacustrine herbarium covers the water surface of this part of the lake, made of hydrophytes (e.g. *Trappa natans*, *Myriophyllum spicatum*, *Ceratophyllum demersum* and others) and helophytes (*Scirpus lacustris Typha latifolia and Fragmites australis*) whose nutrition regulates nutrient flow and provides a self-purification service.

The second gradient defined by the CS3 component describes an aspect of lake water transparency based on the results of the multispati-PCA. This expression is structured by the turbidity and biomass density of microalgae. Solid inputs from the watershed depend on soil texture. The Western and North-Eastern slopes of the sandy-clay and marly (the Numidian Oligocene) provide fine textured inputs (clay-sablo-silty-silty), while the Eastern slope, which is predominantly sandy (the Pleistocene), generates a coarse sandy texture (Joleaud, 1936), which generates less turbulence and therefore has only a limited effect on transparency. Phytoplankton blooms reduce water transparency. Sustained fertility thresholds increase the expression of turbidity and consequently transparency becomes the main limiting factor that hinders the progress of biological processes.

## Conclusion

Oubeira Lake is a dynamic ecosystem. Its position within the wetland complex of the Northeast region of Algeria is crucial for the multiple functions and ecosystem services including the service of purification and regulation of the trophic level.

This study allowed us first to establish the eutrophication level that dominates the surface water quality of Lake Oubeira. To this end, we emphasize the preponderant role of phosphates and nitrates, which in many situations transgress the quality standards. This fertility potential led to phytoplankton blooms characterized by high levels of chlorophyll-a which gave Lake Oubeira the status of eutrophic hyper-eutrophic. Due to advance alteration level, several processes ensuring proper functioning and ecological balance are relatively inefficient.

From the space aspect, the study revealed the expression of a structured organization following orientations defining two gradients. The East-West gradient, on a major axis, shows at its end two levels of eutrophication and pollution calling back for an upstream-downstream effect. The Northeast, South-West gradient, which defines the transparency expression of Oubeira Lake, is a worldwide known ecosystem. Preserving its integrity against pollution and eutrophication has been the main objective of the present study through a spatial analysis. The results revealed an organization of spatial patterns along two orientation gradients. This arrangement reflects a functional aspect inherent to the biological and geochemical potential of Oubeira Lake. These results present a direct implication in the field of the management and conservation of the ecosystems by the adjustment of the functionality level. The dynamic equilibrium that characterizes the eutrophication cycle depends on the intensity matter flows that generate anthropogenic and natural factors. Intervening to insure the equilibrium of this ecosystem, through the regulation of material flows, is the major concern that will lead to the maintenance and stability of all the functions and services provided by this fragile ecosystem.

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