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Physical-chemical Characterization of an Aquatic ecosystem Waters: case of Oubeira Lake (Extreme Northeastern Algeria).

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ABSTRACT
The Oubeira Lake is a freshwater lake, shallow, with an area of 21.73 km2, located in the extreme Algerian Northeast. It is endorheic and Ramsar site since 1983, part of the national park of El Kala. It receives wastewater discharges from small towns and sudden withdrawals for agricultural activities. These actions have so far little effect on the physical and chemical characteristics of water. To study this aquatic ecosystem twenty-four observation stations have been previously identified along six transects to allow a diagnosis of the typology of the lake based on physico-chemical parameters measured in-situ and laboratory. Water analyses of Lake Oubeira, highlighted the presence of dissolved organic nitrogen. To oversee the evolution of NOD, it was important to have a predictive model most suited to modeling the lake.

KEYWORDS: Lake, Oubeira, silica, dissolved organic nitrogen. Prediction.

INTRODUCTION

The Mediterranean periphery lakes, especially those located in North Africa, are experiencing a qualitative and quantitative deterioration resulting from natural constraints (Precipitations, runoff, siltation) and anthropogenic (withdrawals, discharges). This degradation has affected the economic development of the region [1].

Oubeira lake, which still maintains since the Quaternary, has dried up completely at the end of the summer of 1990 following significant pumping for water supply and to a sequence of dry years. Therefore, the same water potential if enough is not endless [2]. The alternation of wet and dry seasons, climate changes, anthropogenic actions and silting of the lake lead to environmental degradation and changes in the structure and functioning of the ecosystem. From a scientific point of view, environmental control campaigns produce large amounts of data very often not easy to interpret. Technical multivariate statistics (PCA, classification methods) for data interpretation seem an interesting solution for a better understanding of water quality and ecological status of the studied areas [3; 4]. In this context, the use of different technical multivariate statistics (PCA, classification methods) for data interpretation [5] seems an interesting solution for a better understanding of water quality and ecological status of the studied environments.

The topic of this current investigation is to make the diagnosis of the lake waters type through the physical and chemical parameters measured in-situ and in the laboratory by the Principal Component Analysis and to identify potentially interesting variables modeling; in addition, it aims to predict the dissolved organic Nitrogen evolution.

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MATERIELS AND METHODES

Overview of the study area:

Oubeira Lake, the target site of this study is located in the far Northeastern Algeria -36 ° 51'N 8 ° 23'E-, at 23 m height and on 21.73 km^2 surface (Fig. 1). It is essentially rainfed, its major tributaries are the wadis called Demenet Er Rehan, Degrah and Bouhchicha. It follows that the hydrological regime is linked to climatic conditions.

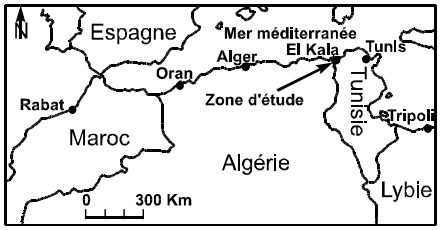

Fig. 1: Location map of the study area

To better monitor and limit anthropogenic effects, Twenty-four observation stations have been previously identified along six transects (Fig. 2) and ten physicochemical parameters were measured in situ and / or in the laboratory.

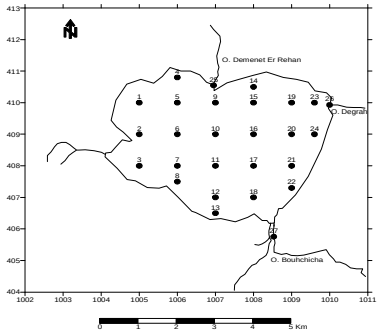

Fig. 2: observation station localization

Measurements And Samples In-Situ Measurements Are Made:

- The location of measuring stations and sampling with a Garmin GPS 72 instrument.
- The electrical conductivity and water temperature were taken with a conductivity-meter (HACH)
- The pH with a pH meter (HACH)
- Dissolved oxygen with an oximeter WTW

Water sampling for physico-chemical analyzes were carried out using a sample bottle in the middle of each vertical, due to the water shallowness and transferred to glass bottles , labeled, previously rinsed with the lake water to be analyzed. They allowed the concentrations determination:

- Nitrates by ion chromatography
- Major cations by ICP-AES
- Dissolved organic nitrogen -Note NOD- and -Note orthosilicates Si (OH) 4- spectrophotometrically

Presentation And Discussion Of Results:

Descriptive Analysis of Results:

The thermal recording is essential to understand the biological, chemical and mineralogical processes occurring in a lake. A temperature rise greatly disturbs the environment, but can also be a factor in the biological productivity increasing [6]. Temperature in Oubeira water varies between 18 and 22°C, which classify it in the category of hot monomictic lakes [7]. The temperature difference between water and air is 3 to 4°C.

Dissolved oxygen essentially depends on respiration and photosynthesis of planktonic populations and biomass mineralization [8]. The dissolved oxygen content in water is closely related to the thermal regime of the lake [9]. In fact, low values of dissolved oxygen observed through this ecosystem are due to the water temperature and the degradation of biomass by microorganisms. Dissolved oxygen in the lake is poor (oscilating between 1 and 3 mg/l.

The electrical conductivity -noted CE- provides a satisfying appreciation for the minarelisation level of a water where every ion acts by its contraction and specific conductivity [10]. The interest of EC measures is most evident in their spatial evolution. It fluctuates between 300 and 500 s / Cm. It characterizes low mineralized freshwater[11] .

The turbidity measurement allows accurate visual information on water [12]. It reflects the presence of suspended particles in the water (organic debris, clays, microscopic organism...). It helps reducing photosynthesis and lowers the dissolved oxygen content [13]. The measurements carried out show that the turbidity varies between 20 and 120 NTU (nephelometric turbidity unit). According to Rodier, the Oubeira lake water is cloudy. The opacity variations are explained by algal proliferation, following the increase of nutrient reserves, carried by tributaries and solid transfer.

Exchangeable bases originate from the dissolution of carbonate formations, sandstone and clay watershed. Carbonate precipitation at the lake level depends on the content of CO2 and pH. Potassium exceeds the recommended standards by [14]. At stations 5, 8, 14, 19; it peaked into 42 mg / l- at the station 13. This component contributes to the proliferation of invasive aquatic vegetation of the lake. Consequently, sodium exceeds standards only at stations 5 and 13 where it is 320 mg / l.

Silicon is the most abundant element in the crust. It is present in geological formations of the watershed including clays and sandstone. The orthosilicic acid Si (OH) $_4$ is the soluble form of silicon having a particularly high bioavailability. Silica flux changes are dependent on lithology, the rate of erosion, climate and production diatoms [15]. In the Lake waters the contents of Si (OH) $_4$ are between 1 and 7.56 mg / l. The highest value is observed at the station 22. This element is generally high, due to the watershed alteration.

In the aquatic environment, the NOD derives from the metabolism of micro-organisms, cell lysis, from the decomposition of organic matter and rainwater [16]. It is used by bacteria as a nitrogen resource and regenerated minerals form (NID) assimilated by plants. The values are ranging between 0.03 and 0.5 mg /l; the NOD is usually a large stock across the lake. This organic fraction plays an important ecological role.

Nitrates derive from the digestion of the lake biomass and the oxidation of ammonia nitrogen and nitrite. Data collected across Oubeira lake are enough low, they vary between 1.15 and 1.46 mg / l. that a small amount of nitrates in surface waters is linked either to increased algae growth in these sites or the spouse denitrification phenomenon that transforms the NO3 nitrate into nitrogen N2 with the presence of organic matter[17].

Statistical Analysis Of Results:

Statistical analysis of the physico-chemical data were on a data matrix consisting of two variables and 24 samples distributed along six transects through Lake Oubeira -either 10 variables, 24 individuals-. The correlation matrix gives us a first idea of the existing associations between variables such as turbidity and silica, potassium, dissolved oxygen, sodium temperature and electrical conductivity. These parameters are relatively well correlated Table1

Table 1: Correlation matrix

	NO_3^-	T	O_2	TUR	K^+	Na^+	Ca^{2+}	CE	$Si(OH)_4$	NOD
NO_3^-	1									
T	-0,3866	1								
O_2	-0,2843	0,4414	1							
TUR	0,2026	-0,2847	-0,1816	1						
K^+	-0,2315	0,3513	0,2725	0,3948	1					
Na^+	-0,1819	0,3664	0,2448	0,4809	0,9777	1				
Ca^{2+}	0,0081	0,0073	0,1157	0,2686	0,7753	0,7113	1			
CE	0,5038	-0,7575	-0,6017	0,1130	-0,5939	-0,5902	-0,1485	1		
$Si(OH)_4$	0,3725	-0,4387	-0,4125	0,8372	0,1787	0,2163	0,1740	0,3449	1	
NOD	-0,4877	0,5476	0,4183	-0,1027	0,2678	0,3216	-0,1929	-0,7215	-0,3129	1

The analysis of variance of the parameters studied shows a significant change between the variables Table 2. The test Ficher calculated is higher than the theoretical F 5% but lower than the theoretical.

NOD Prediction:

Multiple linear regression is a powerful statistical tool that models a random variable values (denoted Y) based on several explanatory variables (X1 noted, X2 ... Xn). The model is [18]. generally used to produce new values. The general shape of theoretical multiple linear regression model is written as described in [19; 20].

With:

Y: Dependent variable (explained);

X1, Xn: independent variable (predictor);

A0 ... An: model settings estimated with the least squares method;

Ɛ: Residue.

The quality of fit is assessed using the correlation coefficient R.

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Multiple Linear Regressions:

To predict the NOD evolution based on major elements (Ca, Na, K, NO3, Si (OH) 4, O2, T EC Tur) the multiple regression is required, by its flexibility depending on the sample size. The linear model suggests a relation of the type:

$NOD = 0{,}39270 - 0{,}03092*NO^{3-} - 0{,}00160*T - 0{,}01629*O_2 + 0{,}00021*TUR - 0{,}00800*K^+ + 0{,}00087*Na^+ - 0{,}00276*Ca^{2+} - 0{,}00055*CE + 0{,}00311*Si(OH)_4$

The correlation coefficient or empirical explanation of the multiple regression model is 0.83. The variance analysis shows that the calculated Fischer test is higher than the theoretical Fischer test. This Model is significant at P <0.05 (or P <0.02), however only nitrates (variables) are significant at P <0.05, the others are high insignificant.

Table 2: Analysis of variance

Source	DDL	Sum of squares	Average square	F	Pr > F
Model	9	0,3475	0,0386	3,3534	0,0211
Error	14	0,1612	0,0115		
total corrected	23	0,5087			

The point cloud of the levels observed in NOD based contents estimated by the model may fit a type of line Y = a.X. However, single high values NOD deviate from the domain of trust at 95% (Fig. 3). The model developed by multiple linear regressions method of is satisfactory, he explained 83% variance.

Table 3: Model Parameters

Source	Value	standard error	T	Pr > |t|	Lower bound (95%)	upper bound. (95%)
Constant	0,3927	0,5055	0,7769	0,4502	-0,6915	1,4768
NO^{3-}	0,0309	0,0382	0,8092	0,4319	-0,1129	0,0510
T	0,0016	0,0194	0,0825	0,9354	-0,0431	0,0399
O_2	0,0163	0,0286	0,5691	0,5783	-0,0777	0,0451
TUR	0,0002	0,0004	0,5650	0,5810	-0,0006	0,0010
K^+	0,0080	0,0147	0,5426	0,5960	-0,0396	0,0236
Na^+	0,0009	0,0016	0,5512	0,5902	-0,0025	0,0043
Ca^{2+}	0,0028	0,0079	0,3499	0,7317	-0,0197	0,0141
CE	0,0006	0,0003	1,9334	0,0737	-0,0012	0,0001
$Si(OH)_4$	0,0031	0,0306	0,1017	0,9205	-0,0624	0,0686

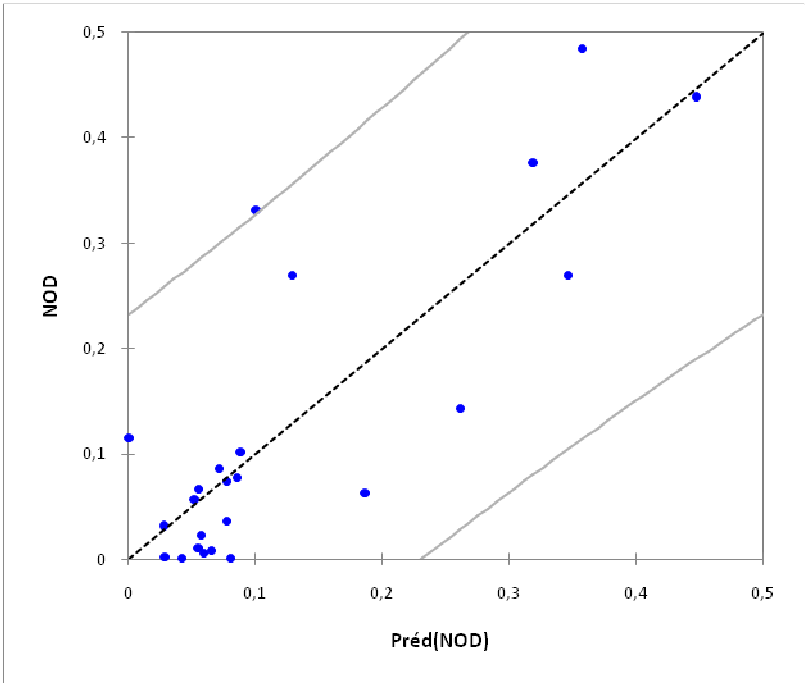

Fig. 3: Levels observed in NOD based contents estimated by the mode

The correlation coefficient obtained by the MLR model is R = 0.83. This shows that the levels of NOD are significantly correlated in a linear fashion with all the other physico-chemical parameters.

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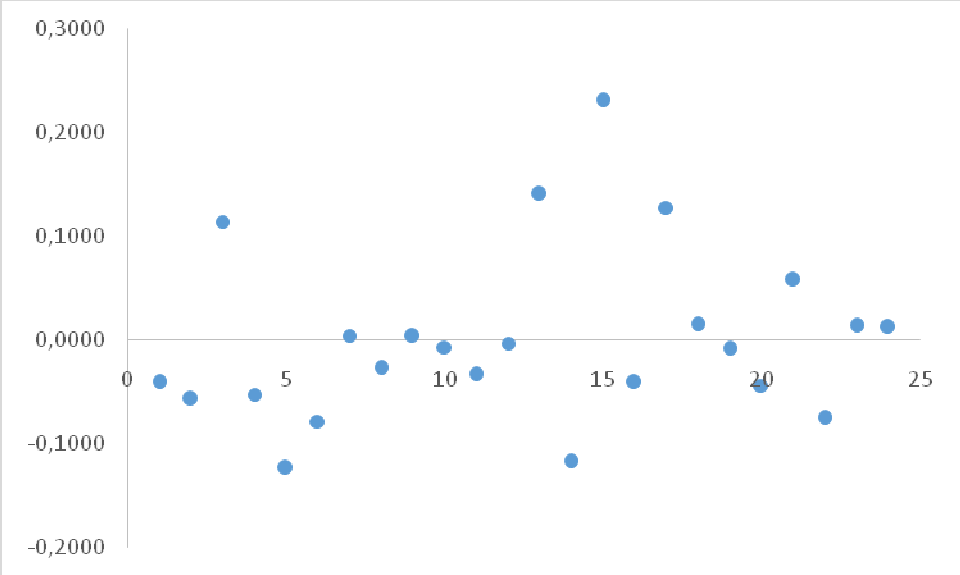

Fig. 4: Relations between the estimated values of NOD and their residues with the models established by the MLR.

From a practical point of view, for environmental prediction of physicochemical parameters, nonlinear components of the studied systems and the number of variables become more important. It is preferable to explore nonlinear models such as artificial neural networks.

Conclusion :

As a part of the ecosystem preservation, a study of physical and chemical parameters has shown that soft and slightly mineralized waters of the Oubeira lake are disorders and low regarding dissolved oxygen. The biomass degradation and temperature readings significantly affect the amount of the oxygen dissolved in water.

The alkaline earth element raised across the lake in the places exceeding the standards recommended by the OMS, in particular at the station 13. Silicon is generally abundant in the lake. It helped focus the importance of the erosion of the watershed through silica and exchangeable bases.

The organic fraction of nitrogen is generally important through the ecosystem. However, self-purification activated by water continuously brewing that the nitrate content is low and shows no particular deterioration in water quality which is the cause of eutrophication. However, the proliferation of aquatic vegetations invading the ecosystem shows the importance of nutrient substances. The model developed by multiple linear regressions method of is satisfactory, he explained 83% variance.

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