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Modeling and Optimization the Conductivity of Natural Waters (Bouregreg River, Morocco) in Terms of Chlorides (Cl^-), Sulfates (SO_4^{2-}), Bicarbonates (HCO_3^-) and Nitrate (NO_3^-)

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ABSTRACT

The Bouregreg River is located on the Moroccan Atlantic coast between Rabat and Sale. It length is 24000meteras well the width average is 150 meter. This river receives wastewater discharges, solid and atmospheric fallen of many development works as well as industrial and agricultural activities, which present a threat to this ecosystem.The primary aim of this study, therefore, was to follow the conductivity variation of Bouregreg river natural waters according to the concentration of some anions (chlorides (Cl^-), sulfates (SO_4^{2-}), bicarbonates (HCO_3^-) and nitrate (NO_3^-)) to determine the ions that have an effect on the conductivity.The second objective is to apply the method of experimental designs and isoresponsescurves for modeling and optimization of this parameter as a function of analyzed anions in Bouregreg natural waters.

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INTRODUCTION

The study of chemical composition of river waters is important not only for determining erosion rates, but also to learn about sources of elements to rivers, mineral weathering and elemental mobility. In addition, information on river chemistry is essential to assess water quality for domestic, agricultural and industrial usage. Chemical weathering of rocks and minerals determines the flux of dissolved materials carried by rivers, whereas physical weathering regulates the particulate transport [1].

Natural water quality is a combination of their ionic composition, their mineralization, the dissolved organic matter content, and the total and permanent hardness. Mineralization of waters is dominated by some substances dissolved in water as electrically charged ions (major ions) [2,3,4,5,6].

The objective of this study is to follow the variation in concentrations of some anions (chlorides, sulfates, bicarbonates and nitrates) on the conductivity of the water for the modeling and optimization of this parameter in natural waters of the BouregregRiver by a statistical treatment of analytical results collected.

MATERIALS AND METHODS

Sampling:

The samples were collected at several sites upstream of Bouregreg River near the Sidi Mohamed Ben Abdellah Dam. The distance between the various sites on average is 100 meter and the time is about 7 minutes.

Chemical Analysis:

We studied the effect of chlorides, sulfates, bicarbonates and nitrates on the conductivity of natural water of Bouregreg River. For measure this physicochemical parameter, the electrode is immersed in the solution and we read the value. The measurement result is shown in µS/cm. the conductivity is measured by the unit CONSORT C831, has a temperature of 21 °C.

Statistical Analysis:

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With the aim to understand the influence of some chemical elements on the change in the value of the conductivity of natural waters were determined isoresponse curves of the conductivity as a function of the anions studied using JMP software [7].

RESULTS AND DISCUSSION

Modeling the conductivity of natural waters of BouregregRiver:

To study the effect of four anions in natural water, we used natural waters of Bouregreg River Dam.The raw surface water used for modeling and optimizing the conductivity was measured with levels of chlorides, sulfates, nitrates and bicarbonates are summarized in Table 1, was carried out after the implementation of anexperiencesplan to know the effect of these elements on the conductivity.

Table1: Results for the various elements in natural water of BouregregRiver.

sample	conductivity (µS/cm)	[Cl^-] (mg/L)	[SO_4^{2-}] (mg/L)	[HCO_3^-] (mg/L)	[NO_3^-] (mg/L)
natural water	324	33.40	39.73	97.63	16.16

To determine the effect of these four anions on the conductivity, we proceed to the application of a composite plan for this we add the four anions Cl^-, SO_4^{2-}, HCO_3^- and NO_3^-synthetically prepared from NaCl, $MgSO_4$, $NaHCO_3$ and $NaNO_3$ in 100 mL of the crude sample, then the answer is the conductivity according to the protocol of the centered composite plane is measured[8,9].

Experimental results:

At a temperature of 21 °C, we have measured the conductivity of the prepared solutions, the pH is around 8. The results found are shown in Table 2, which shows the matrix of experiments:

Table 2: Experimental conditions and measured responses to natural water.

N exp.	X_1	X_2	X_3	X_4	Y (responses)
1	-	-	-	-	444
2	+	-	-	-	48600
3	-	+	-	-	4820
4	+	+	-	-	51400
5	-	-	+	-	2720
6	+	-	+	-	50200
7	-	+	+	-	6830
8	+	+	+	-	52400
9	-	-	-	+	644
10	+	-	-	+	48800
11	-	+	-	+	5050
12	+	+	-	+	51600
13	-	-	+	+	2950
14	+	-	+	+	50400
15	-	+	+	+	7090
16	+	+	+	+	52800
17	-2	0	0	0	2830
18	+2	0	0	0	3370
19	0	-2	0	0	3270
20	0	+2	0	0	3310
21	0	0	-2	0	32400
22	0	0	+2	0	3280
23	0	0	0	-2	3270
24	0	0	0	+2	3290
25	0	0	0	0	3280
26	0	0	0	0	3270
27	0	0	0	0	3280
28	0	0	0	0	3280
29	0	0	0	0	3280
30	0	0	0	0	3280
31	0	0	0	0	3280

Interpretation of results:

Using the 31 experiments, we established the mathematical expression connecting the experimental response to the coded variables. The results of calculations of model coefficients of natural water conductivity are reported in Table 3.

Table 3: Model Coefficient for the Y values and the standard error of natural water.

Coefficients	Estimated Coefficient	standard error	t exp	Confidence level
a_0	3278,57	269,98	0,46	0,65
a_1	125	18,911	0,03	0,97
a_2	588	97,911	0,15	0,88
a_3	-1292	317,91	-0,34	0,74
a_4	15652,17	817,98	4,10	0,0008
a_{11}	3358,15	34,895	0,96	0,35
a_{12}	16,25	4,9067	0,01	0,99
a_{22}	3405,65	97,685	0,97	0,34
a_{31}	16,25	5,6007	0,01	0,99
a_{32}	-95,75	6,0967	-0,02	0,98
a_{33}	7043,15	347,85	2,01	0,06
a_{41}	5	0,9967	0,01	0,99
a_{42}	-202	46,967	-0,04	0,97
a_{43}	-427	45,967	-0,09	0,93
a_{44}	3405,65	47,698	0,97	0,34

The mathematical model of the conductivity as a function of the four studied anions(chlorides, sulfates, bicarbonates and nitrates) in natural water of Bouregreg River is written as:

$$\mathbf{Y\ (conductivity) = 3278{,}5714 + 125.\ X_1 + 588.\ X_2 - 1292.\ X_3 + 15652{,}167.\ X_4 + 3358{,}1488.\ X_1^2 + 16{,}25.\ X_{12} + 3405{,}6488.\ X_2^2 + 16{,}25.\ X_{31} - 95{,}75.\ X_{32} + 7043{,}1488.\ X_3^2 + 5.\ X_{41} - 202.\ X_{42} - 427.\ X_{43} + 3405{,}6488.\ X4^2.}$$

A significance level of 90% (confidence level 90%) only the coefficients a_0, a_1, a_2, a_{12}, a_{13}, a_{23}, a_{41}, a_{42} and a_{43} can be considered significant. The estimated natural water model can be written as:

$$\mathbf{\hat{Y} = 3278{,}57 + 125.\ X_1 + 588.\ X_2 + 16{,}25.\ X_{12} + 16{,}25.\ X_{31} - 95{,}75.\ X_{32} + 5.\ X_{41} - 202.\ X_{42} - 427.\ X_{43}.}$$

(±0.46) (±0.03) (±0.15) (±0.01) (±0.01) (±0.02) (±0.01) (±0.04) (±0.09)

X1: the chlorides content;
X2: the sulfates content;
X12: the interaction between chlorides and sulfates;
X13: the interaction between chlorides and bicarbonates;
X23: Interaction between sulfates and bicarbonates;
X14: the interaction between the chlorides and nitrates;
X24: Interaction between sulfates and nitrates;
X34: the interaction between the nitrates and bicarbonates.

The analysis of this model has led us to exclude the non-significant parameters ($[HCO_3^-]$ and $[NO_3^-]$) and to highlight interactions between chlorides and sulfates, chlorides and bicarbonates, sulfates and bicarbonates, chlorides and nitrates, sulfates and nitrates and between bicarbonates and nitrates.

Optimization of natural water conductivity:

The model above is found for plotting the response surfaces which are shown in Fig. 5, 6 and 7 which respectively represent the isoresponses conductivity curves in the plans: [chloride content (X1) * content sulfates (X2)], [chloride content (X1) * bicarbonates content (X3)] and [sulfates content (X2) * bicarbonates content (X3)], that is to say the most influential factors.

Optimization of chloride content and sulfate content:

The isoresponses curves of the conductivity represented in Fig.1 show that the optimum is located in a chloride content of 750 mg / L and a sulfates content of 400 mg / L.

Optimization of the chloride content and the bicarbonates content:

The isoresponses curves of the conductivity represented in Fig. 2 show that the optimum is located in a chloride content of 750 mg/L and a bicarbonates content of 150 mg/L.

Optimization of the sulfates content and the bicarbonates content:

The isoresponses curves of the conductivity represented in Fig. 3 show that the optimum is located in a sulfates content of 400 mg/L and a bicarbonates content of 150 mg/L.

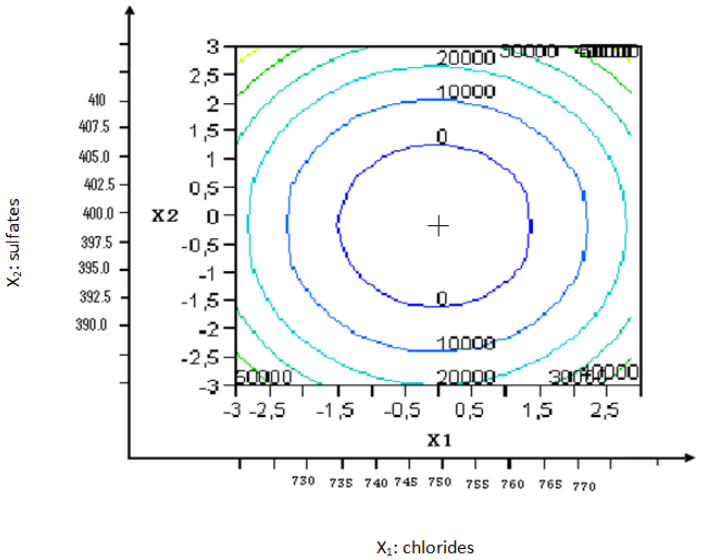

Fig 1: Curve isoresponses conductivity of natural water depending on the content of sulfates and chlorides.To: $[HCO_3^-]$ = 125 mg/L, $[NO_3^-]$ = 46 mg/L.

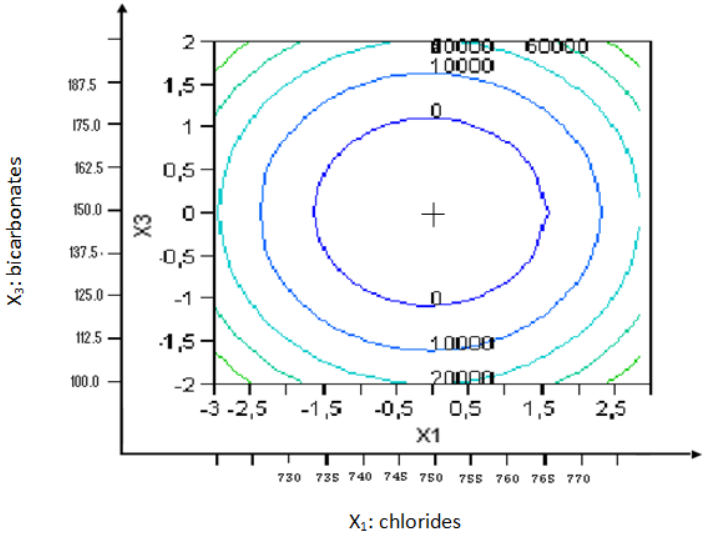

Fig. 2: Curve isoresponses conductivity of natural water depending on the content of chlorides and bicarbonates.To: $[SO_4^{2-}]$ = 405 mg/L, $[NO_3^-]$ = 46 mg/L.

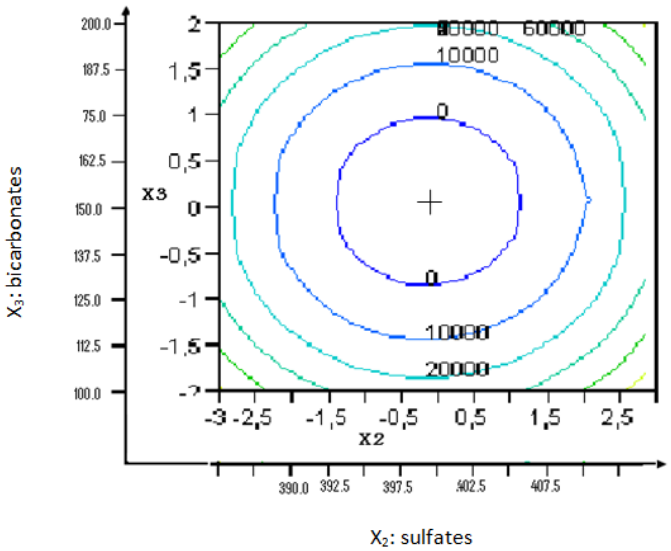

Fig. 3: Curve isoresponses conductivity of natural water depending on the content of sulfates and bicarbonates.To: $[Cl^-]$ = 740 mg/L, $[NO_3^-]$ = 48 mg/L.

Conclusion:

The study of the effect of anions (chlorides, sulfates, nitrates and bicarbonates) on the conductivity of water allowed us to select the factors influencing this physicochemical parameter are the chlorides and sulfates, and spread the nitrate ions which have no effect. Thus it was determined the mathematical model of the conductivity curves isoresponses according analyzed anions in natural water of the Bouregreg river using the method of experimental designs.

Moreover, the mathematical model shows that nitrate ions have no effect on the conductivity of naturel water, but they have a weak interaction with sulfates and bicarbonates in natural water.

REFERENCES

[1] Semwal, N.and J.S.Jangwan,2009.Major ion chemistry of river bhagirathiandriverkosi in the uttarakhandHimalaya.Int. J. Chem. Sci., 7(2): 607-616.
[2] Bchitou, R., A. Bouhaouss, A. Foutlane, 2006. The exchange of phosphorus and nitrogen ions in watersedimentinterface in Sebouriver (Morocco), 31: 99-105.
[3] Laftouhi, N., M. Vanclooster, M. Jalal, O. Witam, M. Aboufirassi, M. Bahir and É. Persoons, 2003.
[4] Zerki, N., R. Bchitou, A. Bouhaouss, 2011. Characterization of some trace elements in natural waters of the Bouregreg estuary (Rabat, Morocco) by a chemometric study. Phys. Chem. News, 59: 121-126.
[5] Zerki, N., R. Bchitou, A. Bouhaouss, 2012. Modeling and optimization the effect of some anions on the water conductivity. Australian Journal of Basic and Applied Sciences, 6(10): 396-402.
[6] Laftouhi, NE., Vanclooster, M., Jalal, M., Witam, O.,Groundwater nitrate pollution in the Essaouira Basin (Morocco), Geoscience, 335: 307-317.
[7] JMP Version 3.2 Introduction guide.User's guide and Statistic and Graphics Guide, SAS Institute, USA.1995.
[8] Foucart, T., 1982. Analyse factorielle programmation sur microordinateur, méthodes et programme. Ed Masson.
[9] Saporta, G., 1978. Théories et méthodes de la statistique Ed.Technop, Paris, pp: 493.