

QUALITY CONTROL OF SURFACE WATER QUALITY: A CASE STUDY OF THE LAKE ALEG IN MAURITANIA

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ABSTRACT

Water quality observation data were collected from 10 representative monitoring sites located in the main stream of the Aleg's lake, Mauritania and its major tributaries between 2016 and 2018.

The Brakna region (Aleg, Mauritania) is symptomatic to the general State of the Mauritanian Sahel, which was hit by a desertification that has been steadily increasing over the last decades. It results in a strong reduction, or even a local loss, of the potential agro-sylvo-pastoral production, leading to a genuine risk for the populations' survival or at least an aggravation of poverty. All this has not been without impact on a highly deteriorated environment and a lastingly mortgaged socio-economic development. In the light of this situation, we will be studying the hydrochemistry of the surface water of Aleg's lake in Mauritania. After many years of domestic exploitation, both industrial and agricultural, besides climate change, it is interesting to ensure water's quality. With this intention, we have tried to realise a physicochemical analysis, an evaluation, to have an idea on the evolution of the chemical facies of Aleg's lake's water.

For this, a sampling has been done for both dry seasons and wintering of the year 2017 at the 10 stations on both of the lake's shores. The following physicochemical parameters are: T, pH, C.E, Ca^{2+} , Mg^{2+} , Na^+ , K^+ , Cl, HCO_3^- and SO_4^{2-} . These measures include the volumetric and the spectroscopic analyses.

The statistical exploitation of the results and their comparison with the interpretation of Piper's diagram, the results of the present study have shown that the lake's water in general has a bicarbonate calcic and magnesian facies for water at all sampling stations.

As well as the evaluation of the analysis of the physicochemical parameters of the water of Aleg's lake presented in this work, it showed that the pH is close to neutrality: 7.43, the mineralization is average due to the conductivity presenting an average of 313.5 $\mu S/cm$. the average values of the calcium, magnesium, sodium and potassium ions are, respectively, 28.75 mg/L, 21 mg/L, 28.92 mg/L and 18.54 mg/L and the sulphate contents of the samples are very low: 22.13 mg/L. these results meet the FAO norms.

Keywords: Water quality, Hydrochimy, Piper's Diagram, Standards, Irrigation, the Aleg's lake, Mauritania.

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1. INTRODUCTION

Water resources play an important role in the development of different sectors in any country. The surface water is likely to be used as drinking and irrigation water [1]. It is the case of Aleg's lake which plays an important role as a primary source of surface water in Mauritania. Moreover, the lake is Aleg city's drinking and irrigation water's supply source in several villages in the zone of Brakna [2].

In this country, where the climate is arid and dry, a water resource management seems necessary. In fact, with low rainfall, the geologic nature of the country and the high evaporation rate make the country lacking resource water. Aleg's lake, located in the Brakna region in the south-west of Mauritania, is characterised by a hot climate (annual average temperature greater than 35°C) of Saharo-Sahelian type with a hot season that lasts 8 months

(from November to June) [3]. The wintering, or rainy season, that follows generally lasts four months, with a peak in pluviometry in August (250-400 mm of rain/year).

The filling dynamic of Aleg's lake depends directly for the main part on the occasional flows of Oued Ketchi, the most important endorheic waterway in the region of Brakna. These flows only happen during the rainy season from July to October. The water finishes its course in the lake, which is a shallow depression [4].

Aleg's lake's surface area of water varies between 0 and 60 km² (south-west of Mauritania, Brakna region). Located in an arid region, the lake is a fragile wetland. It is currently subjected to a significant demographic pressure due to the arrival of the nomads, victims of the increasing drought of the Sahel. The study of this zone's hydraulic operating is currently in the making, in order to reach a relative stability of the lake's water level [5].

Currently and since many years, this vital river has been exposed to some constraints that threaten its physical, chemical and metallic qualities. With diverse geographical points, this lake receives the releases of domestic waste water [6].

The objective of this study is to evaluate the physicochemical qualities of Aleg's lake's water in Mauritania by the chemical facies of the seasonal surveillance.

2. ENVIRONMENTAL STUDY

2.1. PRESENTATION OF THE STUDIED AREA

The Islamic Republic of Mauritania's surface area is 1 025 520 kilometres square, and its position is between latitudes 15 and 27° north. It is bordering Algeria (463 km), Morocco (1 561 km), Mali (2 237 km) and Senegal. It is bordered on the west by the Atlantic Ocean (700 km) (Fig 1).

The prefecture of Brakna has 240 000 inhabitants, namely 10% of the national population established in five administrative departments covering 3% of the national territory. This population is at most 95% of settled people. If the departments of Aleg and Magta-Iahjar have the lowest densities (bigger surface areas), the populations are mostly gathered around Aleg's lake [7]. Aleg is colonial city that was created at the beginning of the XXth century (1903-1904) and that has become the administrative centre of the region of Brakna. This administrative rank bestows upon it an equipment level that is high for a Mauritanian city of approximately 7 000 inhabitants. The region's economic activity is essentially geared towards agriculture which generates a local craft (small shops of all types, markets, ovine and caprine fair, etc.) [8]. The city also has a commercial activity that is favoured by its position on the Hope Road, a paved road that allowed the opening up of Mauritania's southern regions and that connects the capital Nouakchott to Nema.

Aleg's lake, located in the Brakna region in the south-west of Mauritania, is characterised by a hot climate (annual average temperature greater than 35°C) of Saharo-Sahelian type with a hot season that lasts 8 months (from November to June) [9]. The wintering, or rainy season, that follows generally lasts four months, with a peak in pluviometry in August. The filling dynamic of Aleg's lake depends directly for the main part on the occasional flows of Oued Ketchi, the most important endorheic waterway in the region of Brakna. These flows only happen during the rainy season from July to October. The water finishes its course in the lake, which is a shallow depression [10]. Aleg's lake's surface area of water varies between 0 and 60 km² (south-west of Mauritania, Brakna region). Located in an arid region, the lake is a fragile wetland. It is currently subjected to a significant demographic pressure due to the arrival of the nomads, victims of the increasing drought of the Sahel. The study of this zone's

hydraulic operating is currently in the making, in order to reach a relative stability of the lake's water level [11].

In our study, we have chosen as a site the lake area of the river, precisely the Mauritanian city Aleg for many reasons. It is the most dynamic city of the zone and the studied environment receives the domestic discharges and industrial waste.

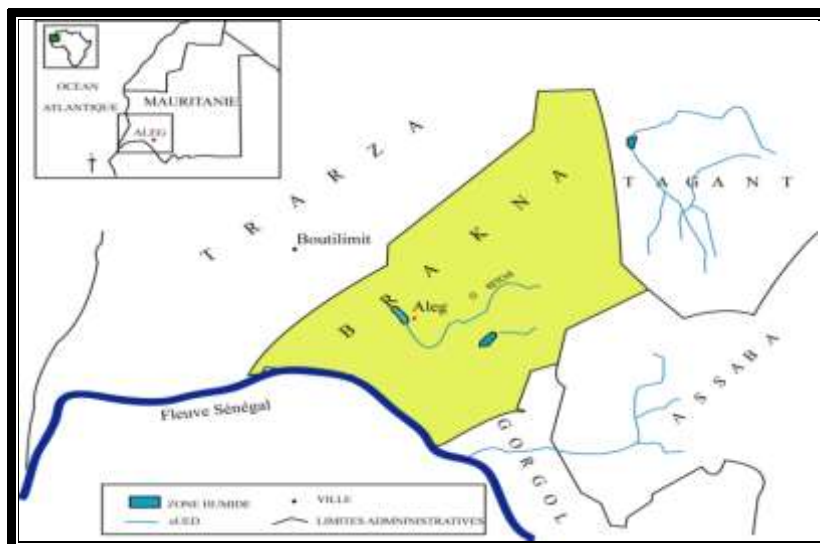


Figure 1: Localization of the study area in Mauritania. Aleg's wetland situation in the regional context of the Mauritanian south-west [12].

3. MATERIALS AND METHODS

3.1. CHOICE OF SAMPLING LOCATIONS

This study was conducted at the Lake dleg in the Brakna region, south-west of Mauritania. This zone extends between 17° 09' 30"N, 14° 02' 05"W and 17° 02' 30"N and 13° 57' 12"W. It covers an area of 0 km2. [13] (Fig.2)

In order to evaluate the quality of the lake's water, we have chosen ten sampling stations located on both of the lake's shores. These stations have been selected on the basis of their accessibility, proximity and in accordance with the agricultural and pastoral activities. Pollution sources and their geographical distribution is as follows (Table1):

Table 1: Sampling of the water of Aleg's lake in Mauritania

Local name	Abreviations	Water Code Station numbers in Aleg	GPS Coordinates	
			X (N)	Y (W0)
Mechraa	Aleg1	01	613227	1887411
Akrraye	Aleg2	02	611481	1889442
Mechraa veived	Aleg3	03	608175	1892163
Dwalek	Aleg4	04	605451	1895255
Mechraa elbel	Aleg5	05	602155	1896292
Engabe	Aleg6	06	600797	1894442
Mechraa Levreiwatt1	Aleg7	07	602754	1892872
Mechraa Levreiwatt2	Aleg8	08	605703	1890386
Mechraa Lejhare	Aleg9	09	608881	1887981
Avreiraye	Aleg10	10	611045	1885859

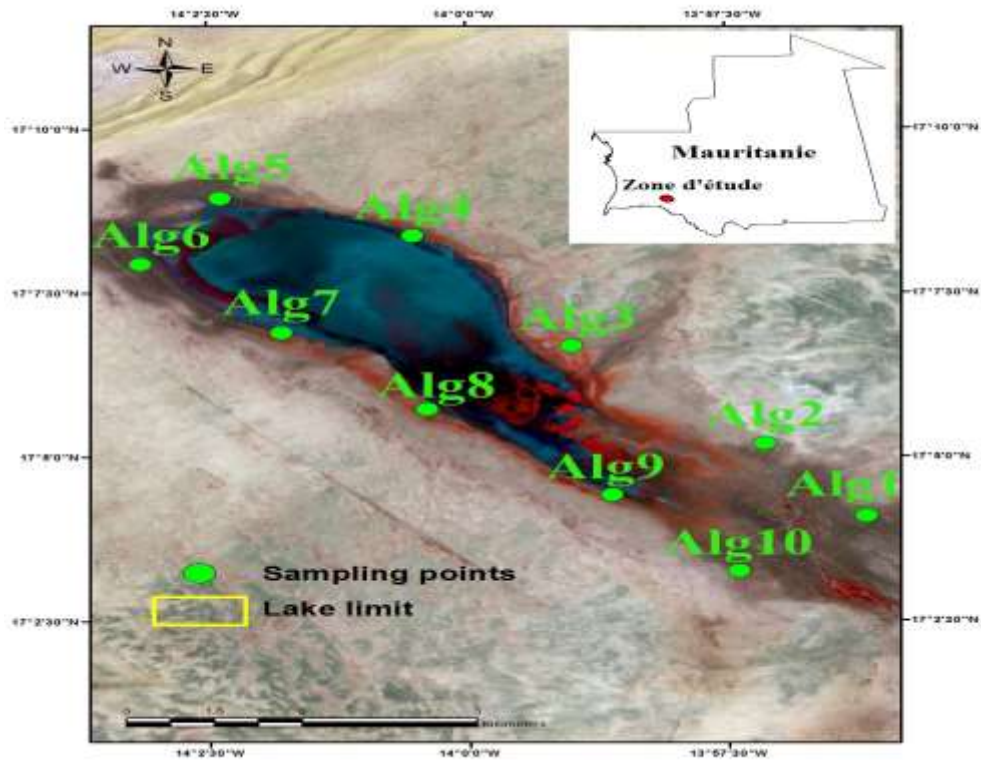


Figure 2: Study area and Water sampling Stations in the study area located in the Lake Aleg south-west of Mauritania [14]

3.2. SAMPLING

3.2.1. Methods of Analysis:-

The sampling of the water of Aleg's lake has been done in February 2017 for the dry season and in August 2017 for the wintering season[15].

These samplings have been done in clean plastic bottles of 1 litre that have been rinsed beforehand with the taken water, totally immersed in the river water and they are hermetically filled in order to avoid any contamination (Photo 1) [16].

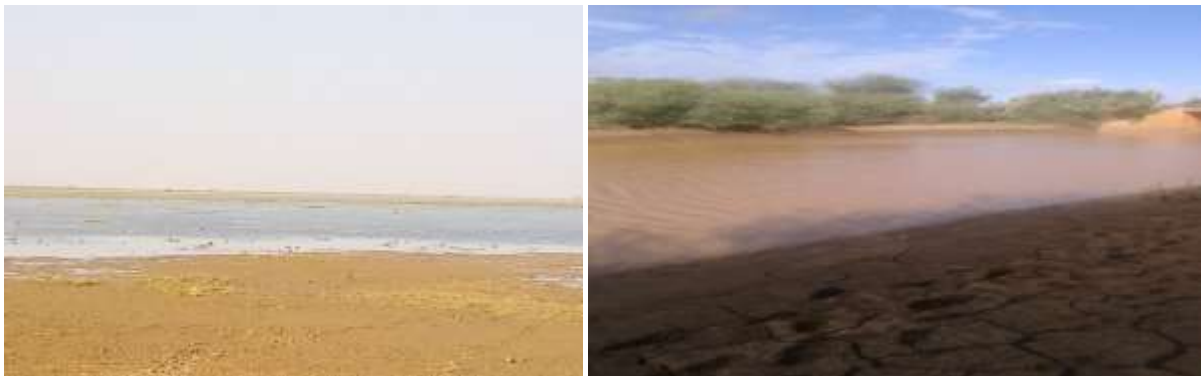


Photo1: Scenery of the zone of Aleg's lake in Mauritania, February, August 2017

3.3. ANALYSIS METHODS

At the same time as taking the test sample of water, we have proceeded to measuring the temperature of the water and the pH is measured using a pH measures portable of brand HANNA series 9,024. The electric conductivity (E.C.) has been measured, using a conductivity meter of type HANNA instrument HI 8733. The Sulphates (SO₄²⁻) are dosed using a UV- Visible Spectrophotometer (WEG 7100).

The Sodium (Na⁺) and Potassium (K⁺) alkaline metals are dosed using a flame photometer. Calcium (Ca²⁺), magnesium (Mg²⁺), chloride (Cl⁻) and bicarbonates (HCO₃⁻) are dosed by volumetric methods of Mohr in the presence of the selective mediums (Rodier, 1996).

The analyses were carried out within the research unit Water-pollution and Environment at the University of Nouakchott Al- Aassriya[17].

4. RESULTS AND DISCUSSION

These results are exploited by the statistical analysis and their comparison to the interpretation of Piper's diagram.

The physicochemical quality of the raw water of Aleg's lake in Mauritania has been monitored through the analysis of the water taken from ten (10) sites. for both seasons dry season (Table 2) and rainy season (Table.3)

4.1. PARAMETERS' EVOLUTION

Table2: Physicochemical results dry season February (2017) average results of water parameters

Code Station numbers in Aleg	PH	T	Cond.	Cl-	HCO ₃ ⁻	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NO ₃ ⁻	SO ₄ ²⁻
		(°C)	µs/cm	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Alg 01	7,02	20	518	35,5	320,25	40,08	26,244	32	24	12,6	58
Alg 02	7,14	23	444	28,4	259,25	46,49	30,618	29	22	10	61
Alg 03	7,3	23,5	339	31,95	198,25	28,05	21,87	25	20	9	27
Alg 04	7,52	24	382	17,75	189,1	34,47	34,506	26	20	15	22
Alg 05	7,42	24	393	24,85	231,8	33,67	19,44	26	20	11,8	51
Alg 06	7,55	24	364	24,85	195,2	16,03	24,786	27	25	6	21
Alg 07	7,51	23	410	46,15	207,4	33,67	23,328	31	26	8	9
Alg 08	7,56	23,6	624	78,1	341,6	54,5	44,712	46	31	13,8	10
Alg 09	7,6	24	346	24,85	189,1	29,66	20,898	27	21	3,8	14
Alg 10	7,62	23,7	702	102,95	274,5	40,88	45,198	51	35	5,4	10
Maximum	7,62	24	702	102,95	341,6	54,5	45,198	51	35	15	61
Minimum	7,02	20	339	17,75	189,1	16,03	19,44	25	20	3,8	9
Average	7,424	23,28	452,2	41,535	244,76	35,75	29,16	32	24	9,54	28,3

Table 3: Physicochemical results wintering season August (2017) average results of water parameters

Code Station numbers in Aleg	pH	T	Cond.	Cl ⁻	HCO ₃ ⁻	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NO ₃ ⁻	SO ₄ ⁻²
		(°C)	µs/cm	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Alg 01	7,15	30,3	101	10,65	54,9	14,4	10,2	20	14	0,52	41
Alg 02	7,2	30,2	107	10,65	42,7	18,43	5,83	14	12	0,54	19
Alg 03	7,29	30,3	109	17,75	97,6	32,86	13,6	12	9	2	10
Alg 04	7,5	30,3	257	28,4	103,7	32,8	16,52	13	9	0,38	5
Alg 05	7,48	30,2	259	14,2	103,7	16,8	16,03	13	9	0,74	1
Alg 06	7,55	30,2	182	10,65	91,5	18,43	17,49	13	15	0,2	1
Alg 07	7,63	30,1	220	17,75	73,2	24,84	11,66	15	15	0,3	20
Alg 08	7,6	30,3	220	17,75	115,9	28,05	13,12	25	18	0,54	2
Alg 09	7,64	30,2	187	14,2	48,8	18,43	11,17	13	12	0,54	2
Alg 10	7,65	30,2	67	7,1	36,6	10,42	6,8	26	10	0,52	36
Maximum	7,15	30,1	67	7,1	36,6	10,42	5,83	12	9	0,2	1
Minimum	7,65	30,3	259	28,4	115,9	32,86	17,49	26	18	2	41
Average	7,46	30,23	169,58	15,38	76,76	21,56	12,15	16,83	12,5	0,71	14,92

Table 4: Physicochemical results annual (2017) average results of water parameters

Parameters	Unit	Minimum	Maximum	Average	FAO 1979[6].		
					Not of problems	Increasing problems	serious problems
pH		7,09	7,64	7,43	6.5 -8.4		
T	°C	25,15	27 ,15	26,76		-	
CE	µs/cm	224	422	313,46	< 750	750 - 2000	> 3000
Ca ²⁺	mg/l	41,28	17,23	28,75	-	-	-
Mg ²⁺	mg/l	28,92	16,03	21,48	-	-	-
Na ⁺	mg/l	38,5	18,5	24,92	-	-	-
K ⁺	mg/l	24,5	14,5	18,54	-	-	-
HCO ₃ ⁻	mg/l	228,75	118,95	161,27	< 9 1.5	91.5 – 518.5	> 518.5
NO ₃ ⁻	mg/l	2,7	7,69	5,09	<5	5.0-30	> 30
Cl ⁻	mg/l	55,025	17,75	29,58	< 142	142 – 355	>355
SO ₄ ⁻²	mg/l	49	6	22,13			

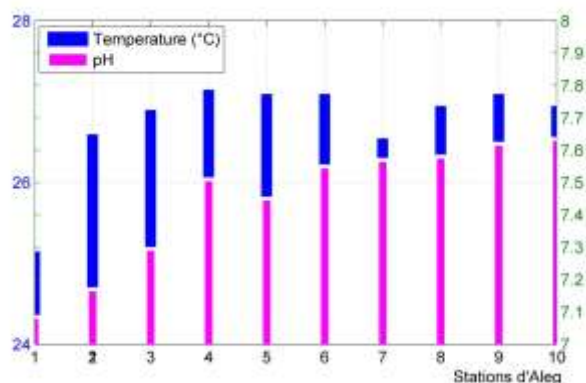


Figure 3: Annual variations of the pH and temperature

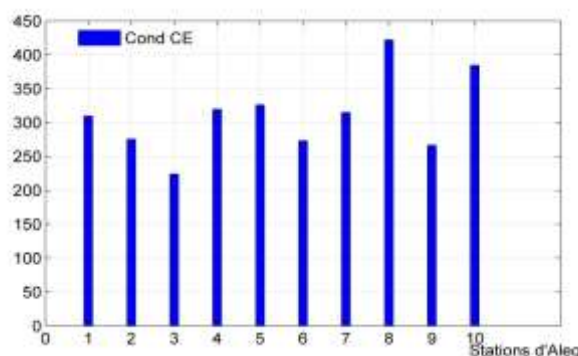


Figure 4: Spatial variations of the electric conductivity E.C. in (µS/cm)

The analyses carried out show that the annual average temperature of the samples is between 25°C and 27°C (Fig 3). Their pH as well is between 7.09 and 7.64 and is within the normal range (from 6.5 to 8.4) according to the FAO directives (Fig 3). Concerning the mineralisation of the lake’s raw water, the measures of the annual average conductivity of the all the samples show that they are between 224 µS/cm and 422 µS/cm (Fig 4), and lower than the grid (750 µS/cm), the water is indexed in the “Not of Problems” category. Thus, no permeability problem that is linked to the total salinity is to be considered (Table 4).

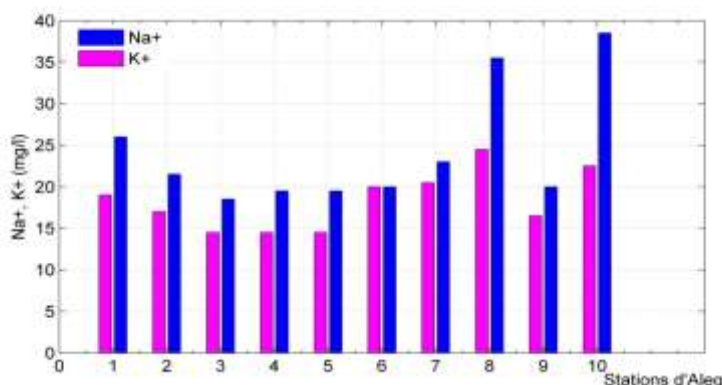


Figure 5: Spatial variations of Sodium (Na⁺) and Potassium (K⁺)

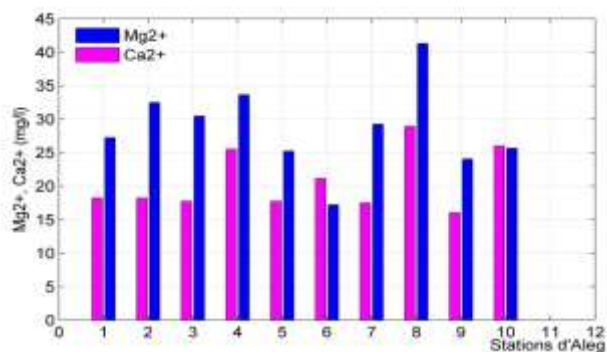


Figure 6: Spatial variations of Calcium (Ca²⁺) and Magnesium (Mg²⁺).

The annual average contents of Sodium and Potassium in the samples vary respectively from 18,5 mg/L to 38,5 mg/L and from 14,5 mg/L to 24,5 mg/L (Fig 5). The annual average contents in Calcium and Magnesium vary respectively from 17,23 mg/L to 41,28 mg/L and from 16,03 mg/L to 28,92 mg/L (Fig 6).

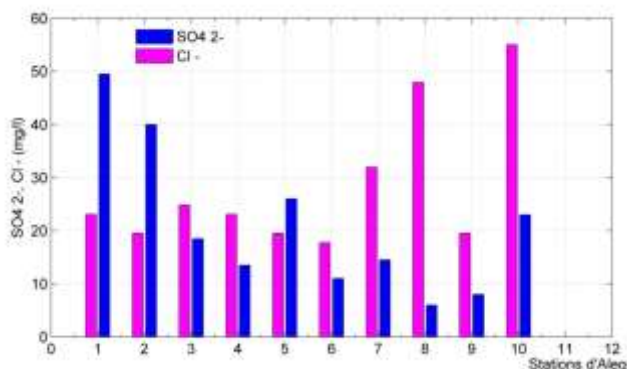


Figure 7: Spatial variations of Chloride (Cl⁻) and Sulphate (SO₄²⁻)

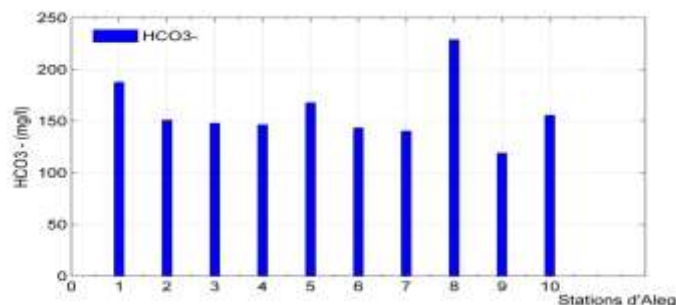


Figure 8: Spatial variations of Bicarbonates (HCO₃⁻)

The average annual contents in Chloride and Bicarbonates vary respectively from 17.75 mg/L to 55.025 mg/L and from 118.95 mg/L and 228.75 mg/L (Fig7). The contents in Sulphate of the samples vary between 6 mg/L and 49 mg/L (Fig8).

4.2. EVALUATION OF PIPER’S DIAGRAM

Piper’s diagram is particularly adapted to the study of the study of the water’s facies when the mineralisation increases (Andreu et al, 2010), [18]; or else to compare the groups of samples in between them and indicate the types of the dominant cations and anions, by using a descriptive and compared approach which allows to represent, on the same graphic, a big

number of monitoring stations allowing a classification by families presenting similar facies. The waters of Aleg's lake have a low mineralisation so their presentation on Piper's diagram will use the simulation and comparison of the waters, spatially and periodically, in order to know the dominant chemical facies in every station and every climatic season. The global presentation of the physicochemical analysis' results, in all stations and at all periods, indicate the presence of different chemical facies (Fig 9) [19].

4.2.1. Piper's Diagram for the dry season

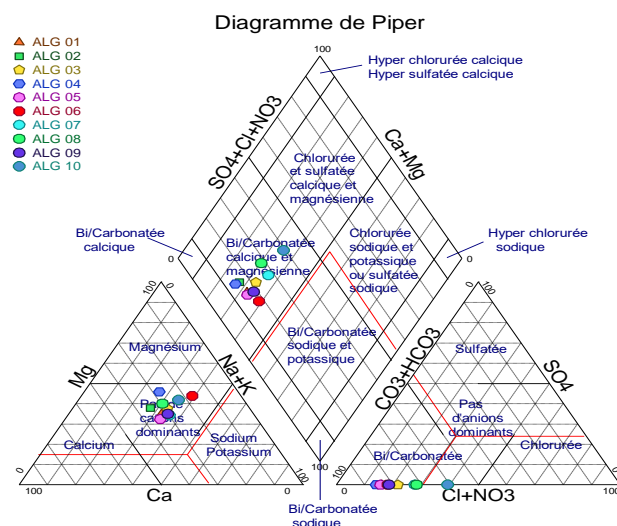


Figure.9: Piper's Diagram for the dry season analysis of water in Aleg's lake (Aleg, Mauritania)

The interpretation of Piper's diagram's graphic representation for the physicochemical results in the studied climatic dry season (Fig 9) allows us to divide water in Aleg's lake (Aleg, Mauritania) into two chemical facies:

- A Calcic and Magnesian Bicarbonate facies
- A Bicarbonate facies
- Without dominant cations for the cations' triangle

4.2.2. Piper's Diagram for the wintering season

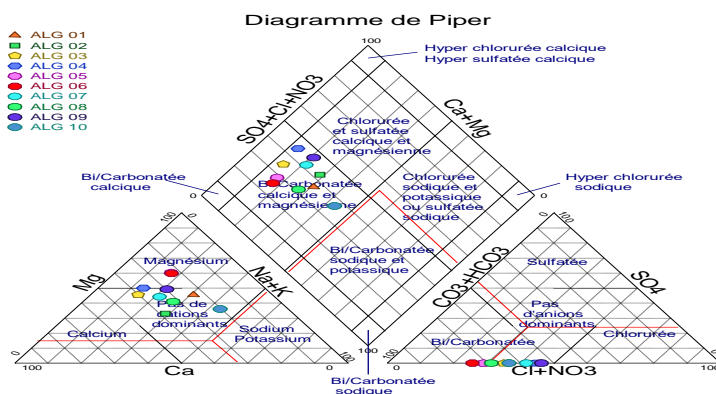


Figure.10 : Piper's Diagram for the wintering season analysis of water in Aleg's lake (Aleg, Mauritania)

The interpretation of Piper's diagram's graphic representation for the physicochemical results in the studied wintering season (Fig 10) allows us to divide water in Aleg's lake (Aleg, Mauritania) into two chemical facies:

- A Calcic and Magnesian Bicarbonate facies
- A Bicarbonate Chloride facies
- Without dominant cations for the cations' triangle

4.2.3. Piper's Diagram of the annual average analysis of waters of Aleg's lake

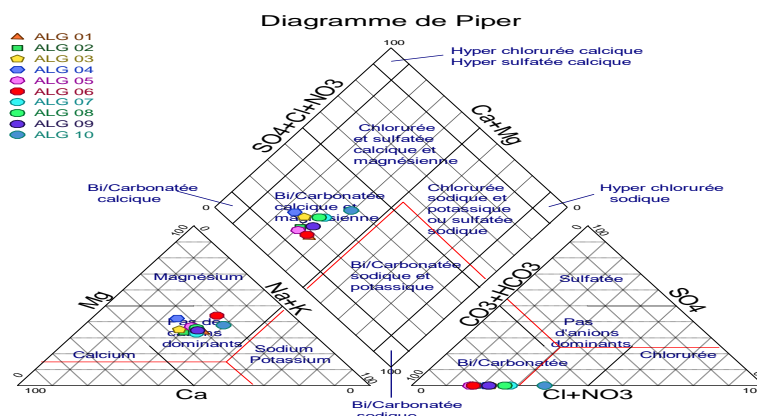


Figure.11: Piper's Diagram of the annual average analysis of waters of Aleg's lake (Aleg, Mauritania)

- To get an idea on these facies, a presentation of the annual average results of the water in stations of (Fig 11) allows us to notice that water in Aleg's lake in general has: a Calcic and Magnesian Bicarbonate facies for water in all sampling stations.

In the context of our study, we have done a total of 10 samplings for the physicochemical analysis. The different samples of raw water in Aleg's lake have been tested in order to be analysed. The samples have been taken in polythene flasks having a capacity of 1 litre.

The electric conductivity translates the degree of global mineralisation, it informs us on the level of salinity [20]. The conductivity measures of the samples show that they are included between 224 $\mu\text{S}/\text{cm}$ and 422 $\mu\text{S}/\text{cm}$

The Calcium and Magnesium contents vary respectively from 17.23 mg/L to 41.28 mg/L and from 16.03 mg/L to 28.92 mg/L (Table.2). The Chloride and Carbonates contents vary respectively from 17.75 mg/L to 55.025 mg/L and from 118.95 mg/L to 228.75 mg/L. The Sulphate contents in the samples vary from 6 mg/L to 49 mg/L (Table.2).

To get an idea on these facies, a presentation of the annual average results of the water in stations of (Fig.3) allows us to notice that water in Aleg's lake in general has: a Calcic and Magnesian Bicarbonate facies for water in all sampling stations.

5. CONCLUSION

The physicochemical parameters collected from superficial water in the lac Aleg in Mauritania vary little from one site to another and do not show an apparent accumulation of metals in the samples analysed.

The results of the physicochemical parameters' analysis of the water in Aleg's lake in Mauritania, presented in this work, used for the irrigation and pastoral work, compared to the

values norms (FAO) have shown that the water in Aleg's lake is categorised in the category "Not of Problems".

The average values, of the calcium, magnesium, sodium and potassium ions are, respectively, 28.75 mg/L, 21,48mg/L, 24,92 mg/L and 18,54 mg/L and The Sulphate contents on the samples are very low at 28.3 mg/L , Thereby, all the waters in Aleg's lake in general have: A Calcic and Magnesian Bicarbonate facies for water in all the sampling stations.

7. ABBREVIATIONS

Aleg: areas of the BRAKNA region (in the south-west of the Mauritania) ,EPE: Pollution and Environment Unit, GEOPAC: Center (geophysics, natural patrimony and green chemistry) KETCHI: the largest river that feeds Lake Aleg, WHO :World Health Organization, E.C: is The electric conductivity , Fe: iron; IQR: interquartile range; MDG: Millennium Development Goals, Mn: manganese, NaCl: sodium chloride, WASH: Water, Sanitation and Hygiene, FAO: Food and Agriculture Organization of the united Nations.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

LGBPN, GEOPAC, and EPE contributed to the data collection. Conducted the data analysis and participated in the result interpretation. Wrote the manuscript. LGBPN, GEOPAC, and EPE commented on the manuscript draft. All authors read and approved the final manuscript.

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