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Study of the Physicochemical Quality of Water in the Djoudj Lake at Bargny (Senegal)

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Abstract*—The objective of this study is to establish relations in order to estimate the evolution of the quality of the water stored by the lake Djoudj in the Bargny quarry so as to of advantage control their industrial and agro-pastoral use. Even if these resources do not constitute a particular problem for an industrial use, they present some chemical elements relating to rates likely to disturb the agro-pastoral use. It is singularly the case of boron, iron, and the nitrite of which their respective contents up of the recommendation. The results collected in the present study classify water of the lake Djoudj in the category of water quality sufficient for irrigation and industrial uses, but of which the drinkable use requires a thorough treatment.*

Keywords— water quality, lake djoudj, bargny, catchment area, pluviometry, granulometry, limit chemical consistency composition of water, turbidity, color, temperature, conductivity, pH, hardness, alkalinity, nitrite, iron, phosphate, boron, chlorine ¶.

I. INTRODUCTION

To enable Bargny population of carry out agro-pastoral and industrial activities with an availability of water all season, artificial lakes are created in this zone namely Djoudj, Arbed and Bargny dam. But the creation of artificial lakes solutions are insufficient because it is they face fills problems **[1, 2]**, losses and the quality of these waters is not mastered.

After a presentation of the area, we do so in this study an analysis of the site's geological composition that contains Lake Djoudj (in our study) before presenting the chemical composition of the lake which is often dependent on nature geological watershed. Targeted components will turbidity, color, temperature, conductivity, pH, hardness, alkalinity, nitrite, iron, phosphate, boron and chlorine.

II. PRESENTATION OF THE STUDIES AREA

The study area is located in Rufisque department, particularly in the town of Bargny.

A. Presentation of Bargny town:

The town of Bargny is located thirty (30) km from Dakar and has geographical coordinates 14 ° 43'19 "N and 17 ° 14'20" W. It is at 23 m altitude.

Figure 1 : Site Location

B. The climate of the study area

The study area are in a tropical climate characterized by the alternation of a rainy season (three (3) months) and a dry season (nine (9) months).

The dry season from October to June is a time swept by the harmattan continental trade wind, hot and dry wind. While the wintering period lasts three (3) months from July to September. During this period, the winds of the trade winds and the monsoon from St. Helena penetrate the country with a high humidity load.

1) Rainfall in the study area

The water potential of the area is similar to that of the country (Senegal) greatly reduced in recent decades. Intervals between 5 and 100 years is sufficient for determining the annual rainfall [3,4,5]. The annual average for Dakar region between 1985 and 2014 is 401.30 mm, with a large variation over the last ten (10) years. The number of days of precipitation per year is very low with an average of 25 days.

2) Temperatures of the study area

The thermal regime in the region has two (2) seasons. The cold season is from December to March and characterized by low temperatures averaging 21 ° C. The maximum average is 28 °C.

C. Geographical delimitation of the study area

The area is between 17 ° 14 West longitudes and 14° 43 north latitudes. This basin was specially created by the cement plant in order to contain the rain water that may hinder the operation of his quarry during the rainy season. This water is also used for industrial operations as well as agro-pastoral needs.

The image below gives an overview the position of the study area.

Djoudj Lake is at a high altitude on a limestone plateau, it has a small area and big depth. Given the importance of this lake for industrial needs, she is currently in full expansion. The specific characteristics of Djoudj before extension are shown in the table below:

Table 1 : Specific characteristics of Djoudj Lake

SETTINGS	VALUES
Filling altitude	12.582 m
Maximum filling height	7.46 m
Filling surface	46,550 m^2
Filling volume	**208,050 m^3**

III. GEOLOGICAL STUDIES OF WATERSHEDS

In a watershed, geology provides information on the history of existing materials on the drainage trajectory of the drainage or hydrographic network.

A. Relief and geological context of the natural site Bargny

The geological composition of the Niayes area is mainly dominated by sands **[6]**. But especially a part of bargny city, sits on a limestone plateau of limestone-Lutetian age. It is a slightly undulating plateau with an average altitude of about twenty meters (30m). It leads to weak slopes which do not allow the thalwegs to sink; the runoff cannot lead to a hierarchical network.

The geological history of this country is a part of Dakar region in general and is marked by a brittle tectonic **[7].**

The geological context of the study area is characterized by essentially marly rocks of the Eocene, covered by black clay sands. What makes it there's a small water infiltration resulting in better water conservation in lakes **[8]**.

B. Geotechnical testing of Bargny natural site

After researching the geology of the site, we did experiments in the laboratory of Thies Polytechnic School on the physical characteristics of soil that makes up the study area. The levies are taken from two samples in Lake Djoudj.

We present and analyze the results of these tests for physical soil identification. In this study, we have targeted the particle size distribution and the consistency limits.

1) Granulometry

Granulometry is one of the most widely used methods for soil classification **[9,10]**.

The granulometry curve allows us to take out the soil synthesis table **[11]** according to the decreasing grain diameter diagram of figure 3.

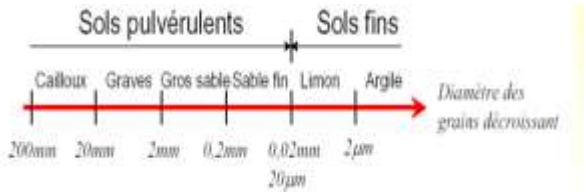


Figure 3 : Decreasing grain diameter diagram

The figures 4 and 5 below are the representation of the particle size curve of two samples taken at two different points of the lake surface.

TAMIS	% PC
19	100
9,5	98,52
4,25	96,084
2	93,319
0,95	91,579
0,42	89,111
0,25	85,137
0,102	80,024
0,075	74,08
0,032	49,844
0,023	48,079
0,015	45,433
0,009	42,786
0,007	38,375
0,005	35,729
0,003	34,846
0,003	33,964
0,002	33,082
0,001	33,435

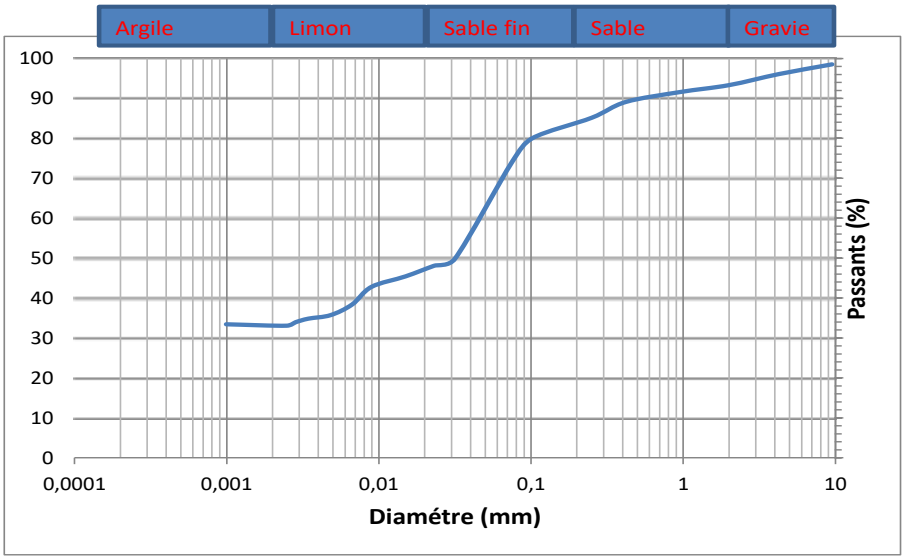


Figure 4 : Sample size curve DJOUDJ Sample 1

TAMIS	% PC
19	100
9,5	99,033
4,25	97,424
2	95,076
0,95	93,71
0,42	91,722
0,25	89,654
0,102	84,992
0,075	80,404
0,032	48,448
0,023	46,651
0,015	43,954
0,009	40,359
0,007	36,763
0,005	34,606
0,003	33,707
0,003	32,808
0,002	32,808
0,001	33,168

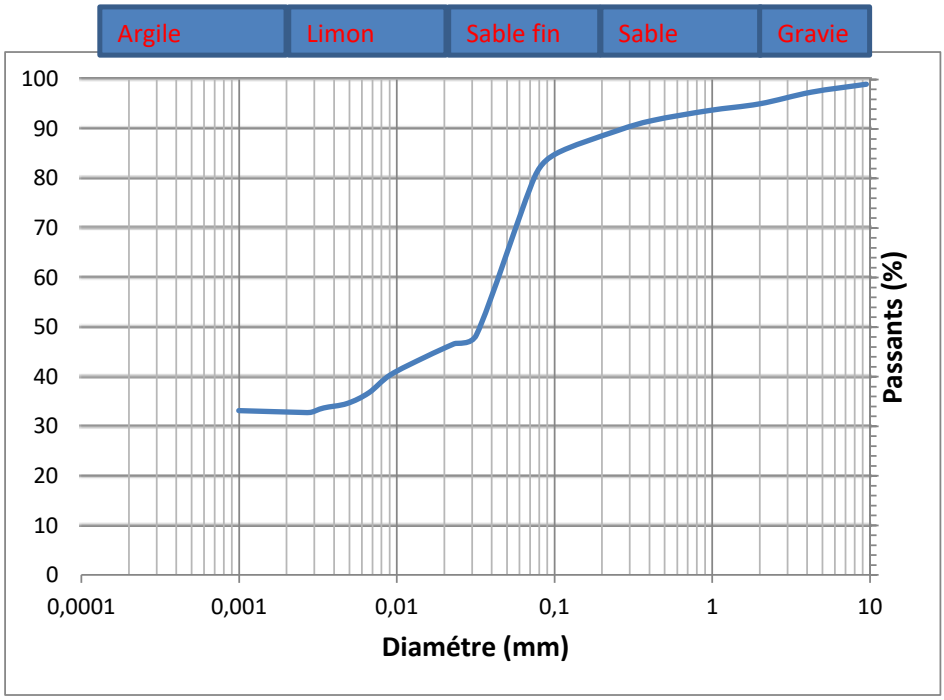


Figure 5 : Sample size curve DJOUDJ Sample 2

Table 2 : Synthesis of particle size analysis of soils Site Djoudj

Particle size class	***Djoudj Sample1***	***Djoudj Sample2***
Gravels	6.68	3.924
Coarse sands	16.32	16.076
Fine sands	29	32
Limons	14	14
Clays	34	33

The composition of Djoudj soils is generally dominated by clay at 33.5% on average and 30.5% of fine sand. Coarse sand is present with an average of 16.2%, as are limons (14%) and 5.3% gravel.

2) Limits of consistency

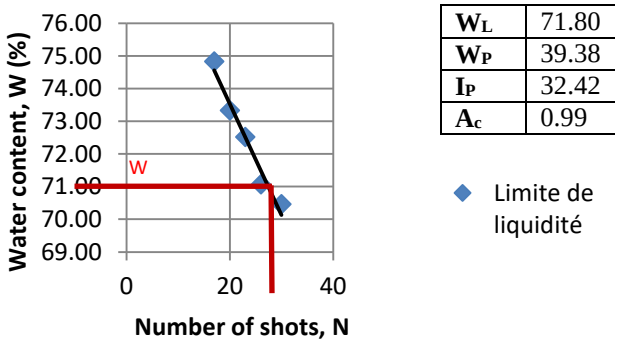
The Atterberg limits here will be used for classification. They constitute an important index in geotechnics and are determined

by the French standard CEN Brussels, NF P 94-051 (1993) **[12]**. These limits are measured with standardized equipment on the mortar, that is to say the fraction of soil passing through the 0.4 mm sieve. They are defined on three (3) limits: liquidity limit (W_L), plasticity limit (W_p), withdrawal limit (W_s) **[13].**
Since we just need to have the plasticity index (I_p) for the classification, we will determine the first two limits (W_L and W_P).
The following formulas allow us to calculate **[13, 14]** :

Plasticity Index: $I_P = W_L - W_P$

Activity $$Ac = \frac{Ip}{\text{water content granulo} < 2\mu m}$$

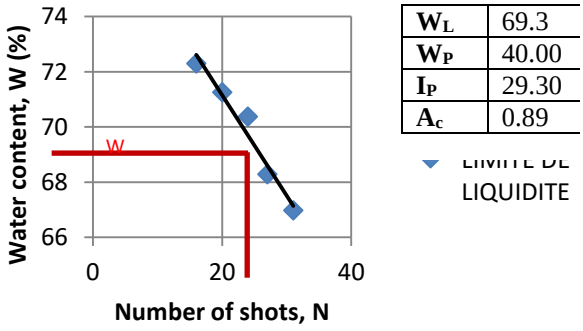
Figure 6 below shows the liquidity limit curve that allows us to determine the WL value of Lake Sample 1.



W_L	71.80
W_P	39.38
I_P	32.42
A_c	0.99

Figure 6 : Liquidity limit of Djoudj Sample 1

Figure 7 below shows the liquidity limit curve that allows us to determine the W_L value of Lake Sample 2.



W_L	69.3
W_P	40.00
I_P	29.30
A_c	0.89

Figure 7 : Liquidity limit of Djoudj Sample 2

The classification we have carried out according to the Plasticity Indices (I_p) shows that the characteristic of the soil of Djoudj Lake is mainly of plastic silty clay **[13, 14]**.
The state of plasticity refers to the property of the wetted materials of the soil, to change shape continuously under the effect of constant pressure. She keeps acquired a new form when the pressure disappears. This characteristic makes it possible for the lake to have a high capacity for retaining rainwater due to their low infiltration **[15]**.
Table 3 below shows the summary of results

Table 3 : Synthesis of Liquid limit results

		Djoudj Sample 1	**Djoudj Sample2**
γs (kN/m3)		27.18	2.752
Granulometry	**< 2 mm**	93.32	95.076
	< 60 µm	58	60
	< 2 µm	34	33
W_L		71.8	69.3
I_P		32.42	29.3
A_c		1.66	1.28

Thus, following the availability of the main trials results, the following table was developed as a synthesis:
Table 4 : Soils classification

Site	***Nature of Soil***
Djoudj Sample1	*Limon very plastic and very plastic organic soil*
Djoudj Sample2	*Limon very plastic and very plastic organic soil*

IV. LAKE WATER QUALITY

In this part of the work, we will study the physical, chemical and organoleptic properties of Djoudj lake water.
We will proceed with the analysis of some important parameters considered or harmful to agricultural development, pastoral and fisheries **[16]**, in order to judge the quality of the water.

A. Materials used

For sampling and testing, the equipment used consists of a cooler for the preservation of samples; a water test kit including a conductivity meter with a built-in thermometer, a HANNA pH meter, a digital camera, a water sampler for deep sampling and 500 ml bottles labeled indicating the origin, place, date and time of collection.
The material used for the analysis in laboratory is composite of a spectrophotometer U 800, reagents for different dosages, bowls, shakers, beakers, flasks and pipettes.

B. Methodology

In this study, water samples were taken in the lake in two different places to obtain representative results. This five sampling campaigns were carried out the first of which took place in February and the second in May. These first two campaigns are done between 6 pm and 8 pm. The remaining samples were conducted between 11am and 1pm in October, November and December. All samples were taken at different depths through the water samplers still resting on the Floating Dock Lake. Superficial samples were also taken from the opposite part of the floating doc.

After sampling, the vials are stored in a cooler in order to avoid chemical reactions which change the chemical composition of water. Apart from on pH testing, conductivity and temperature performed on site, all other tests were done in the laboratory with the spectrophotometer.

C. Presentation and analysis of results

We will in this part of the study presented the results of the various analyzes of qualities and interpreted for an agro-pastoral and fish use. Target nutrients are: turbidity, color, temperature, conductivity, pH, hardness, alkalinity, iron, phosphate, boron, chlorine and nitrite.

1) Turbidity

Table 5 below shows the measurement results of the turbidity from February to December.

Table 5 : Turbidity (unit:fau) in Djoudj Lake between February and December

depth	february	may	october	november	december
Surface	13	29	> 500	> 500	> 500
0.5m	14	29	> 500	> 500	> 500
1m	7	-	> 500	> 500	> 500
1.5m	22	-	> 500	> 500	> 500

Djoudj Lake has an average turbidity of 19 FAU between February and March. The value exceeds 500 FAU between October and December. This increase in turbidity is caused by the presence of suspended solids in water. The point that broadcasts erosion bare soil and crossed the presence of a multitude of bird species from the Djoudj park of Saint-Louis Senegal, staying at the lake, hence its name, can also be the cause of this rise.

2) Color

Table 6 below shows the measurement results of color from May to December.

Table 6 : Colors in pt-co of Djoudj Lake between May and December

depth	may	october	november	december
Surface	135	20	21	50
0.5 m	62	20	21	45
1 m	-	20	22	47
1.5 m	-	21	22	49

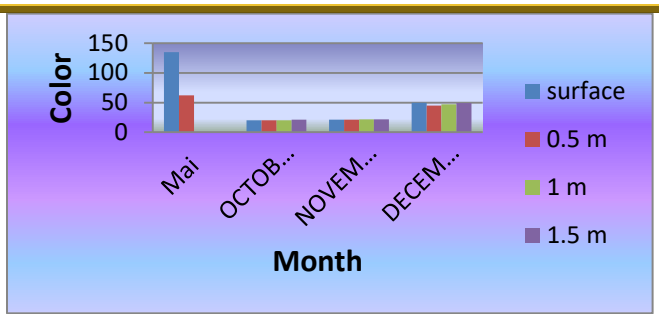


Figure 8: Colors of Djoudj Lake between May and December

According to the results, the range of the observed coloration varies from month to month; and it is strong as a whole with 62 -135 (pt-co) in the month of May, 20 - 22 (pt-co) between October and November 47-50 (pt-co) in December. All these values are above 15 (pt-co) representing the acceptable limit value for judging that water is drinkable **[17, 18].**

In the lake, this color is due to minerals and colored organic matter from decomposition or aqueous extraction of natural vegetation as in the soil leaching, the presence of metals such as iron, manganese and copper. These metals are abundant in nature and are found in the water by the erosion of rocks or corrosion of pipes (for transfer between Arbed and Djoudj Lakes), which alters its color. Colored water is suspect for consumption regardless of its qualities.

3) Temperature

The table 7 below shows the results of measuring the water temperature from February to December.

Table 7 : Temperatures in ° C of Djoudj Lake between February and December

depth	february	may	october	november	december
Surface	22	28.5	33	31.05	27.6
0.5 m	22.2	27.5	32.4	31.2	28.3
1 m	22	-	31.6	30	26.4
1.5 m	22	-	31.9	30.7	27.4

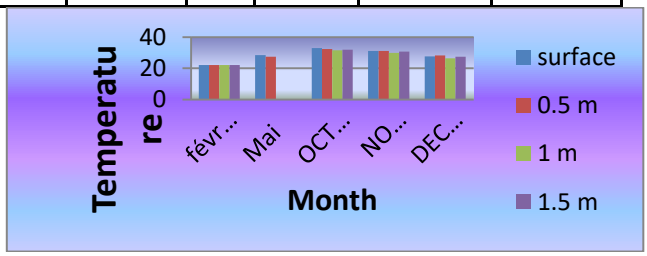


Figure 9 : Temperatures in ° C of Djoudj Lake between February and December

Temperature is a key physical parameter that strongly influences the chemical and biological processes within the lake.

Between February and May, trials were conducted in Djoudj and recorded an average of 24 ° C. Observations from October to December show an average of 31.2 ° C. These values decrease slightly during the month of December to reach 27 ° C

coinciding with the arrival of the cold in Senegal. These variations in the thermal water regime strongly affect the distribution of living species. But they have no particular effect on industrial or agricultural use.

4) Conductivity

The tableau8 below shows the measurement results of the conductivity of water from February to December.

Table 8 : conductivities in µs / cm of Djoudj Lake between February and December

depth	february	may	october	november	december
Surface	5260	7025	1385	1407	1518
0,5 m	5210	6730	1370	1390	1520
1 m	5200	-	1366	1403	1515
1,5 m	5220	-	1364	1401	1511

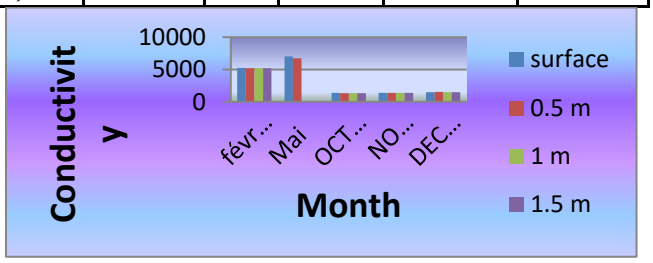


Figure 10 : conductivities in µs / cm of the Djoudj Lake between February and December.

Conductivity is an indicator of the content of dissolved salts **[17]**. It is dependent on the geochemical nature of the rocks encountered in the watershed, and in particular substances from the weathering of rocks. It also depends on the water hardness (calcium, bicarbonates, magnesium). This explains the high conductivity values we have in Djoudj. The watershed of the lake is mainly dominated by the presence of limestone rich in calcium.

As pH, conductivity varies depending on the calco-carbonic balance, so that it also depends on the temperature and biological processes **[17, 19, 20]**. This is why conductivity values are lower in the rainy season due to dilution by rain.

This increase in conductivity in the dry season can be explained by evaporation and high biological activity between December and April because of better climate. This effect is enhanced in lake outfalls due to the primary lacustrine production and resulting calcite precipitation. The conductivity is not directly proportional to the mineralization because it depends not only on the chemical composition but also on the mobility of the ions.

5) pH

Table 9 below shows the results of measuring the pH of water from February to December.

Table 9 : pH of Djoudj Lake between February and December

depth	february	may	october	november	december
Surface	7.01	8.91	9.5	9.05	8.89
0.5 m	7.05	9.11	9.5	9.09	8.82
1 m	7.07	-	9.7	9.09	8.95
1.5 m	6.97	-	9.7	9.12	8.92

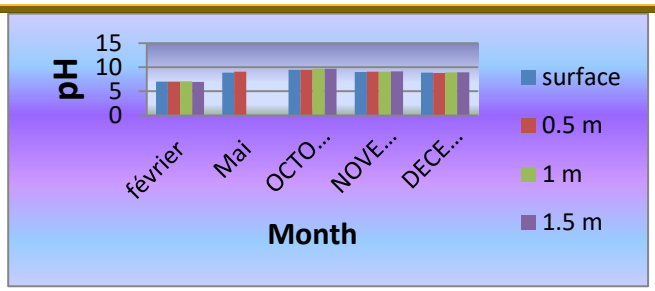


Figure 11 : pH of Djoudj Lake between February and December

The pH of the lake water is determined for the most part by calco-carbonic balances and geochemical composition of the watershed **[21]**. The buffer capacity of the high water, characterize the limestone areas.

This is the case of our study area in which there's a strong presence of limestone, hence the high pH that we found in the various analyzes.

We are seeing a change in pH that is growing between February and December with a fall between December and February.

This can be explained by the fact that other factors influence the pH in this case temperature and biological processes such as photosynthesis or decomposition of organic matter. The growth of the temperature reduces the solubility of CO_2 and consequently decreases the pH value. Photosynthesis uses CO_2 and HCO_3^- in its process, which increases the pH **[21]**.

This means that the annual pH variation curve in a lake often has a sinusoidal due to correlations between pH, temperature and seasonal biological processes.

Low pH water (less than 5) can cause excessive concentrations of toxic substances. They can also promote the development of poor metabolic acidosis in cattle and goats.

The critical acidic pH is about 4.5 for most fish **[22]**. The pH upper limit is about 9.2 for trout **[22]**.

The tables of our measurements show that we have no acid pH in our lake, so no problems related to these water acidities on agriculture, livestock and fish farming.

For against pH values above 9 can promote the dissociation of ammonium to ammonia formation. However, concentrations of ammonia greater than 0.008 mg / l may be toxic to eggs and fish fry, the concentration of 0.02 mg / l is considered as a ceiling **[21]**. We are really facing this problem in our case with a high pH in the months of October, November and December.

The pH should therefore be maintained within a range of 6.5 to 8.5. Its value may become critical in the case of excessive plant production, especially on slow-flowing sections whose shores do not offer shade.

Nevertheless, the pH we found is up to standards for livestock watering which requires values between 6.5 and 9.5 **[23].**

6) Hardness

The Table 10 below shows the measurement results of water hardness from February to December.

Table 10 : Hardness in mg / L ($CaCO_3$) of Djoudj Lake between February and December

depth	february	may	october	november	december
Surface	29	14	24	45	45
0.5 m	25	28	46	43	47
1 m	27	-	< 2	37	39
1.5 m	34	-	< 2	46	40

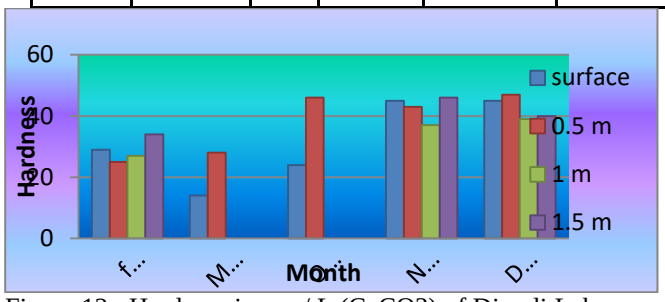


Figure 12 : Hardness in mg / L (CaCO3) of Djoudj Lake between February and December

Hardness is like alkalinity, they risk clogging the taste system by drop. The hardness refers to the amount of magnesium and calcium contained in the water. These magnesium's and calcium's come from the alteration of the bedrock. A lake water rich in calcium and magnesium often have equivalent amounts of bicarbonates or carbonates, which give high hardness. **[24]**.

Evaporation of the water from the drip systems causes the precipitation of magnesium and calcium bicarbonate in the form of flakes and tends to plug the holes.

Overall, we have very soft water in our lake (between 14 and 47 mg / L of CaCO3) up to 1.5 m deep **[25].**

7) AlKalinity

Table 11 below presents the measurement results for alkalinity of water from February to December.

Table 11 : alkalinity in mg / l of Djoudj Lake between February and December

depth	february	may	october	november	december
Surface	10	21	18	16	20
0.5 m	6	21	20	16	12
1 m	6	-	18	15	12
1.5 m	10	-	17	11	19

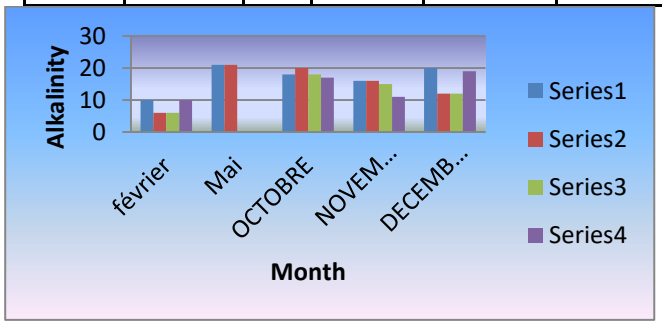


Figure 13 : alkalinity in mg / l of Djoudj Lake between February and December

The irrigation tolerance limit is 200 mg / l **[26, 27]** and 400 mg / l for aquatic animals **[28]**. We are well below the limit values of tolerance.

However alkalinity is a very important nutrient for fish farming, it is a buffered pH and prevents the sudden change of it. If pH of water is less than 6.5, the alkalinity must be between 15 and 20 mg / l to be accepted in fish production **[29]**. On the other hand, the recommended alkalinity concentration range for fish farming is between 75 and 200 mg / L **[30]**.

8) Iron

Table 12 below presents the measurement results for the iron-to-water ratio from May to December.

Table 12 : iron content in mg / l of Djoudj Lake between May and December

depth	may	october	november	december
Surface	0.12	> 3	> 3	> 3
0.5 m	0.12	> 3	> 3	> 3
1 m	-	> 3	> 3	> 3
1.5 m	-	> 3	> 3	> 3

Iron is good for plants but in small quantities, under certain conditions it clogs the emitters. An iron concentration in water between 1 and 2 mg / l is considered optimal for plant nutrition **[25, 31]**. But this rate is high for fish reproduction, which accepts concentrations of less than 0.3 mg / l for small fish and 0.5 mg / l for large fish **[31]**. Healthy water for animal drinking, the iron content must be less than 0.2 mg / l **[32]**. Because a high concentration of iron causes an unpleasant taste and induce a fall in animal consumption.

However, iron as a precipitate (Fe^{+3}) is not toxic, but it can affect the metabolism of fish. It creates interference at the respiration of fish because of its adverse effect **[29]**. Indeed, the fine particles of the metal may be deposited on the eggs and gills by precipitation, and they clog the pores of the membrane of the egg and the epithelium of the gills, which can affect the interference gas exchange. The abrasion effect created by this iron can go as far as to damage the gills, which makes the fish vulnerable to secondary infections by fungi and bacteria. The fineness of the fish gills facilitates the clogging of the iron on them and makes them more fragile, especially the smaller ones, they are more sensitive and bear lower concentrations than the large ones **[28]**. Averaging a rate above 3, the solution must be taken to bring this rate back to acceptable normal.

9) Phosphate

The Table 13 below shows the measurement results on the levels of phosphate in water from February to December.

Table 13 : Phosphate content in mg / l of Djoudj Lake between February and December

depth	february	may	october	november	december
Surface	> 80	> 80	> 80	> 80	> 80
0.5 m	> 80	> 80	> 80	> 80	> 80
1 m	> 80	-	> 80	> 80	> 80

1.5 m	> 80	-	> 80	> 80	> 80

Phosphate is an essential element for the growth and development of plants. It plays a particularly vital role in the development of the root system, on photosynthesis and reproductive plant. Their variations depend on the physicochemical properties of soil **[33].** We generally have high phosphate levels, which is good for gardening.

Generally, this high value of the phosphate concentration is not very troublesome in the biological activity of the lakes. She did not particularly harmful effects, but it is an indicator of anthropogenic pollution **[21]**.

10) Boron

The Table 14 below shows the measurement results on the levels of boron in water from November to December.

Table 14 : Boron content in mg / l of Djoudj Lake between November and December

depth	november	december
Surface	> 2	> 2
0.5 m	> 2	> 2
1 m	> 2	> 2
1.5 m	> 2	> 2

The plant essentially needs boron but at a low concentration in irrigation water. He is involved in the translocation of sugars (to give the nutrient sugars-boron) which allows it to cross membranes and reach the roots to allow breathing. It is essential in flowering, protein synthesis and nitrogen metabolism.

Boron is toxic to plants in different degrees of concentration according to the plant.

An American study gives the tolerances in the table below:

Figure 14 : classification of the boron tolerance for plants **[34]**

< 0,5 mg / l	Satisfactory for all species
0,5 to 1 mg / l	Satisfactory for most crops (sensitive plants however can see their leaves affected)
1 to 2 mg / l	Also suitable for certain species: production of sensitive species is reduced
> 2 mg / l	Only very tolerant plants give satisfactory productions

In our lake, we find a concentration of boron in water above the tolerance limit. Unfortunately, we have not yet discovered in our research an economical solution which eliminates boron from irrigation water and even less of an amendment capable of eliminating its toxic effects.

The standard requires a maximum concentration of 0.8 mg / l of boron to avoid toxic accumulation with sensitive crops such as garlic, beans, lemon, cherry, orange, wheat, sesame, avocado, etc. **[26]**.

If animals absorb the boron, it will disperse in the body before being excreted quickly, some take more time before being eliminated because embedded in the bones. It can sometimes disrupt the development and reproduction of fetuses.

Species such as algae, bacteria, adult fish and invertebrates are tolerant to boron excess.

To prevent the risks of boron, it will cultivate tolerant species such as cabbage, celery, turnip, corn, artichoke, tomato, alfalfa, parsley, asparagus, red pepper, carrot, radish, potato, cucumber **[34]**.

11) Chlorine

The Table 17 below shows the measurement results on the chlorine level in water from November to December.

Tableau 15 : Chlorine content in mg / l of Djoudj Lake between November and December

depth	november	december
Surface	0.19	0.14
0.5 m	0.13	0.14
1 m	0.19	0.13
1.5 m	0.11	0.10

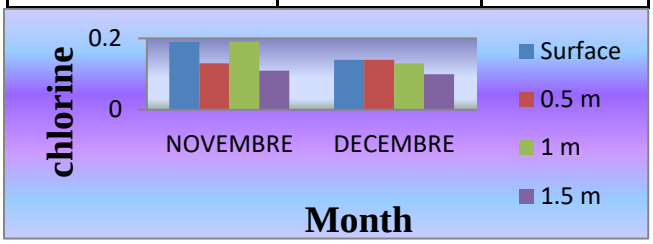


Figure 15 : Chlorine content in mg / l of Djoudj Lake between November and December

Chlorine has a regulating role. It not only contributes to the regulation of the nitrite content in water but maintains hydration and turgidity. It is involved in cell elongation and stomata opening.

For good use of the plant, its content must be between 0 and 100 mg / l **[17, 24]**.

Chlorine present in high concentration can cause an unpleasant taste and induce a water consumption decrease of animals.

In our lake, the chlorine content varied between 0.1 and 0.19 mg / l. These values are well below the maximum value of 100 mg / l that can be contained in irrigation water and therefore the present chlorine content is safe for crops. Similarly, it does not pose a risk for the development of species dependent on the lake, but especially of aquatic species whose proliferation is blocked by this parameter. Chlorinated water can disrupt healthy bacterial growth and harm microorganisms.

12) Nitrite

The tableau12 below shows the measurement results on the nitrite levels in water from October to December.

Table 16 : Nitrite content in mg / l of Djoudj Lake between October and December

depth	october	november	december
Surface	> 0.5	> 0.5	> 0.5
0.5 m	> 0.5	> 0.5	> 0.5
1 m	> 0.5	> 0.5	> 0.5
1.5 m	> 0.5	> 0.5	> 0.5

Nitrites are intermediate products of nitrification, ie the biologically transforming of ammonium into nitrate **[35, 36]**. It is a very toxic component for plants and animals. When nitrites enter the bloodstream, it reacts with hemoglobin and forms a component called methemoglobin. This compound reduces blood capacity to transport oxygen.

Nitrite toxicity is closely related to the concentration of chlorine in water.

Table 17 below proposes the assessment of the nitrite content correlated with that of the chlorine **[21]**:

Tableau 17 : Objectives of nitrites in fish-bearing waters in relation to the presence of chlorine

Chlorine content (mg/l)	Nitrite objective (mg/l)
< 10	0.02
10 – 20	0.05
>20	0.10

The tolerance limit for animal portability of water is much larger; it is in the order of 3 mg / l **[17, 37]**.

The concentration of chlorine in the lake is less than 10 mg / l (0.1 and 0.19 mg / l); we had to find with a nitrite concentration of less than 0.02 mg / l for a better use fish farming. Unfortunately, all samples taken in Djoudj between October and December show nitrite levels above 0.5 mg / l.

This means that fish farming is very risk on this lake if solutions are not found beforehand.

V. Conclusion

The various tests we performed to classify the soils of the study area, lead us to conclude that this soil, marl limestone, Bargny career that houses the Djoudj Lake is composed of very plastic silt and organic soil very plastic.

This soil composition is very influential on the quality of the water it stores although it is not the main actor.

The results of this analyzes carried out over the period from February to December show that the boron, iron and nitrite concentrations exceed the grade recommended by the standard for agro pastoral needs.

However, these concentrations are acceptable for the cement manufacturing needs which are currently the only need industrial zone.

Faced with these water quality problems, appropriate solutions must be studied. An awareness campaign for farmers is also needed to help them to better use.

Other minor elements not taken into account in this study such as chromium, nickel, mercury and selenium may be potentially toxic.

References

[1] **L.J. Gordon, G.D. Peterson and E.M. Bennett**; "Agricultural modifications of hydrological flows create ecological surprises"; Trends Ecol. Evol. 23(4); (2007); pp.211-219.

[2] **P. Hubert and 1.P. Carbonnel**, "Approche statistique de l'aridification de l'Afrique de l'ouest"; J. Hydrol. 95 ;(1987) ; pp.165-183.

[3] **M.L. Lo, A. Ba, E.B. Diaw, A. Diène, M.B. Diop and G. Sissoko**; "Technical Studies of Treatment Basins and Ravines of Area of Sanghe (Senegal)"; Research Journal of Environmental and Earth Sciences; Vol.5, N°11; (2013) ; pp. 660-670.

[4] **B.Y. Moret** ; "Etudes des averses exceptionnelles en Afrique Occidentale." ; Rapport De Synthese ; Synthèse mul ; ORSTOM ; Paris ; (1968).

[5] **P. Hubert, 1. P. Carbonnel and A. Chaouche**, "Segmentation des séries hydrométriques"; Application à des séries de précipitations et de débits de l'Afrique de l'ouest. J. Hydrol. 110 ; (1989) ; pp.349-367.

[6] **M.L. Diallo, E.B. Diaw, A. Diene, P. Demba, M. Ndiaye, A. Diallo And G. Sissoko** ; "Modeling transport in porous solute unsaturated: risk of contamination of groundwater in the area of niayes (Senegal)." International Journal of Civil Engineering, Vol. 2; N°1; (2015) ; pp. 12-21.

[7] Bureau de Recherches Géologiques et Minières (BRGM), **J. Barrère, M. Slansky and M. Arnould** ; "Afrique Occidentale-Carte Géologique." ; WorlCad, carte géographique; (1960).

[8] **P. Gordon, and D. Reeves**; "City of Lake Forest, Illinois"; A Resident Guide for Protecting Ravine and Bluffs; (2007).

[9] **M. M. Rahman, M. H. Rashid, M. A. Hossain, F. S. Adrita and T. Hossain** ; "Mixing time effects on properties of self-compacting concrete." ; ARPN Journal of Engineering and Applied Sciences ; Vol. 6 ; N0 8 ; (2011) ; pp.108-114.

[10] **ASTM** (American Society for Testing and Materials); "Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates." ASTM C136, Annual Book of American Society for Testing Materials Standards; Vol. C; (2006) ; pp. 04.02.

[11] **G. CASTANY** ; "Hydrogéologie, principes et méthodes" ; Edition Dunod ; Université-Bordas ; Paris ; (1982) ; pp. 238.

[12] **A. Cisse, P.G. Lo, E.B. Diaw , S. Sene, M. Diagne, I. Gbaguidi, B.O. Diop, M. B. Mbodj, K. Niang, M.B. Diedhiou and G. Sissoko** ; "Contribution to Improving the Quality of Road Base Layers : Concept of Optimum

Maximum Diameter and its Application to the Laterite of Sindia (SENEGAL)." ; Research Journal of Environmental and Earth Sciences ; Vol.8 ; N°1 ; (2016) ; p. 1-7

[13] NF P94-051 ; "Sols : reconnaissance et essais - Détermination des limites d'Atterberg - Limite de liquidité à la coupelle - Limite de plasticité au rouleau" ; (Mars 1993); pp.15

[14] ASTM D4318-10 (American Society for Testing and Materials); "Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils"; Pa. West Conshohocken; (2010); pp.18.

[15] M.S. Kolawole, A.O. Omali and A. Daniel; "The review of the rate and the hydrological significance of the fast drying up of Lake Chad"; Res. J. Environ. Earth Sci., 4(12): (2012) pp.1002-1010.

[16] S. G. Sarwar and A. Wazir Manzoor; "Physico–chemical characteristics of a fresh water pond of Srinagar (Kashmir)"; Pollution Research; 10(4); (1991); pp.223–227.

[17] M.A. Isah , O.B.E. Salau, A.I. Harir, M.A. Chiroma and A.A. Umaru ; "Parameters of water quality in hand dug wells (hdw) from hardo ward" ; Bauchi Metropolis ; Nigeria ; ARPN Journal of Engineering and Applied Sciences ; Vol. 10 ; N°.16 ; (2015) ; pp. 6804-6810.

[18] R.N. McNeely, V.P. Neimanis and L. Dwyer ; "Water Quality Sourcebook" ; a Guide to Water Quality Parameters ; Environment Canada ; Ottawa ; (1979) ; pp. 88.

[19] JD. Hem; "Study and interpretation of the chemical characteristics of natural water»; USGS Water Supply Paper, 2254; (1985); pp.117–120.

[20] M. Bengoumi, "Qualité de l'eau en aviculture" ; Revue trimestrielle d'information scientifique et technique ; Vol 3 ; N°1 ; (2004) ; pp.5-25.

[21] OFEV (Office fédéral de l'Environnement) ; "Méthodes d'analyse et d'appréciation des cours d'eau" ; Analyses physico-chimiques, nutriments ; (2010).

[22] M. HUET ; "Traité de pisciculture" ; Éditions Ch de Wyngaert, Avenue Georges Henri, 296, 1 200 Bruxelles ; (1970).

[23] OMS (Organisation Mondial de la Santé); "Les lignes directrices de l'OMS en ce qui concerne la qualité de l'eau potable", mises à jour en 2006 sont la référence en ce qui concerne la sécurité en matière d'eau potable ; (2006).

[24] Isabelle COUTURE; "Principaux critères pour évaluer la qualité de l'eau en micro-irrigation"; collogue sur l'irrigation; Centre de Référence en Agriculture et Agroalimentaire du Québec (CRAAQ) ; 10 février 2006; pp 1-12.

[25] Isabelle COUTURE; "Guide de production des annuelles en caissettes"; Centre de Référence en Agriculture et Agroalimentaire du Québec (CRAAQ); 2003; pp.313.

[26] H.G. Peterson; "Water quality and Micro-irrigation for horticulture"; WateResearch Corp. and Agriculture and Agri-Food Canada; (1999), pp.1-36.

[27] M.H. Sheet, "Sewage water irrigation effects on ground water quality in semel area (iraq)" ; ARPN Journal of Engineering and Applied Sciences ; Vol. 7 ; N°. 8; (2012) pp. 971-974.

[28] R. Morin ; "Qualité de l'eau requise pour l'élevage des salmonidés" ; Document d'information DADD-14 ; Ministère de l'Agriculture, des Pêcheries et de l'Alimentation;(2013); pp.25.

[29] SIGMA Environmental Consultants Ltd.; "Summary of water quality criteria for salmonids fishes"; Department of Fisheries and Oceans; SECL 8067; (1983).

[30] Wurts W.A., R.M. Durborow ; "Interactions of pH, carbon dioxide, alkalinity and hardness in fish ponds" ; Southern Regional Aquaculture Center, U.S. ; Publication No. 464, (1982) ; pp.4.

[31] W. Nazif, S. Perveen and S.A. Shah ; "Evaluation of irrigation water for heavy metals of akbarpura area"; Journal of Agricultural and Biological Science ; Vol.1 ; N°.1 ; (JULY 2006) ; pp. 51-54.

[32] F.V.D. HORST ; "Les bonnes pratiques pour une eau de qualité" ; (2007).

[33] A. Elalaoui ; "Fertilisation Minérale des Cultures : Les éléments fertilisants majeurs (Azote, Potassium, Phosphore)" ; Bulletin mensuel d'information et de liaison du PNTA ; (2007).

[34] A. Landreau and L. Monition ; "Nouvelle évaluation de la qualité de l'eau pour l'irrigation" ; (1977).

[35] E.B. Diaw, M.L. Lo, M. Wade, S. Ndao, A. Diallo, And G. Sissoko ; "Modélisation numérique du transport de solutés : prévision des risques de contamination de la nappe des Niayes (Sénégal) par les pesticides." ; International Journal of Innovation and Applied Studies ; Vol. 17 ; N0. 4 ; (2016) ; pp. 1358-1372.

[36] S. Werner, S. Laura and Ph. Behra ; "Chimie des milieux aquatiques, Cours et exercices corrigés" ; Edition Dunod ; Collection : Sciences Sup ; 3ème édition (2005) ; pp. 442-510.

[37] Canadian Council of Ministers of the Environment (CCME) ; "Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses" ; Update 2005 ;