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Hydrochimy of the High Delta of the Senegal River (Rosso, Mauritania)

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ABSTRACT: In this work, we investigate the hydrochimy of surface water of the Senegal River (the Mauritanian delta of the city of Rosso). After several years of domestic exploitation: agricultural and industrial one, besides the climate changes in the area, it is interesting to make sure of the quality of water. With this intention, we tried to carry out a physicochemical evaluation, to have an idea on the probabilities of pollution and the effect of the seasonal variation of the climate on water of this river.
For that a sampling was carried out during every season of 2015 at the five stations on the axis of the river at the city of Rosso. The followed physicochemical parameters are : T°C, pH, C.E, the total hardness (TH), Ca^{2+}, Mg^{2+} , Na^{+}, K^{+} , NH_4^{+}, CL^{-}, NO_2^{-}, NO_3^{-}, HCO_3^{-}, CO_2, SO_4^{--},TA, TAC and suspended matter. These measures comprise volumetric analysis, spectroscopic, Potentiometric.
Statistical exploitation of the results and their comparison with the European standards of potability of water has shown that there is a true deterioration of the quality of water of the Senegal River. The content of nitrite varies between 0.13 mg/l and 1.6 mg/l with an average about 0,55mg/l which exceeds the standard (0.1 mg/l).The content of bicarbonate varies between 18 mg/l and 61 mg/l with average value36, 14mg/L exceeds the standard (30 mg/l).The content of carbon dioxide varies between 6.94 mg/l and 28.45 mg/l with average value 17.26 mg/l exceeds the standard (10 mg/l).
A quality control of water of the Senegal River must be required and updated in particular the reduction of the domestic and industrial effluent of the factories located at the shore of this river.

KEYWORDS: Quality, physic-chemistry, Standards, Climate, Senegal River, Mauritania.

1 INTRODUCTION

Water resources occupy plays an important role in the development of the various sectors in any country. The surface water is likely to be used like drinking waters and water of irrigation. It is the case of the Senegal River which plays a very important part like primary source of surface water for Mauritania. Apart from the Senegal River, there does not exist waterway permanent in the country [1]. Moreover, the Senegal River is the source of supply of Rosso and Nouakchott by drinking water within the framework of the project Aftout EsSaheli.

In this country where the climate is arid and dry, a management of the water resources appears necessary. Indeed, weak pluviometry, the geological nature of the country and the importance of evaporation make the country low in water resources. The delta of the Senegal River is in sub-Saharan zone with weak period between sentences; its climate is of sahélo-Saharan type and generally divided two seasons in the year: the rainy season start from July to September and the season dries by the end of October to June. The dry season, subdivided into two: the cold dry season from October to February and the hot dry season from March to June [2].

Currently and since many years, this vital river exposed constraints which threaten its physical qualities, chemical and metal ones. With various geographical points this waterway receives rejections of waste waters, domestic and industrial [3].

To date, the state of the rivers and the African estuaries were studied very little, whereas they are the place of great demographic trends and receive a volume growing of waste, in particular of domestic waste waters. The only large river of the northwest coast of Africa is the Senegal River which covers nearly 340,000 km2 and extends on four countries (Guinea, Mali, Mauritania and Senegal) [4].

The objective of this study is to evaluate the quality of water of the Senegal River by a monitoring physicochemical space and seasonal.

2 ENVIRONMENTAL STUDY

2.1 PRESENTATION OF THE STUDY AREA

The Islamic Republic of Mauritania is 1 025 520 square kilometers, and its position is between 15th and the 27e northern degree of latitude. It has borders with Algeria (463 km), Morocco (1 561 km), Mali (2 237 km) and Senegal. It is bordered in the west by the Atlantic Ocean (700 km). The borders were traced artificially, which explains the straight lines, except for the Senegal River which constitutes a natural border between Mauritania and Senegal [5].

This river, born in the Fouta Djallon in Guinea, throws itself in the Atlantic Ocean after a few 1770 km. It is the second large river of West Africa after Niger (4 200km).Its catchment area made 337,000 km2 including 60,000 km2 in the national territory of Senegal.

Its principal tributaries, Bafing 750 km, Bakoye 562 km and Falémé 625 km, take their sources in the mountains of Fouta-Djalon. The other tributaries located downstream like Kolimbiné 450 km and Karakoro 310 km are of less importance. Its medium annual currently is about410 m3/s on average [6].

The zone of the delta of the river is west of Trarza in Mauritania downstream from the valley of the river, starting from the zone of widening of the low valley, just upstream of the town of Rosso [7], is divided into three principal zones: the high delta of Rosso until Keur Macene, -the average delta of Keur Macene until Ziré,-the bottom delta of Ziré until N'diago [8].

This delta of the Senegal river approaching several human urban areas (Keur Mesein, Rosso Mauritania…) and an industrial unit, Senegalese Sugar Company (C.S.S) [9].

In our study, we chose like site the zone of the high delta of the river, precisely the Rosso city Mauritania for several reasons. It is the most dynamic city in the zone and the studied medium receives domestic rejections and industrial wastes.

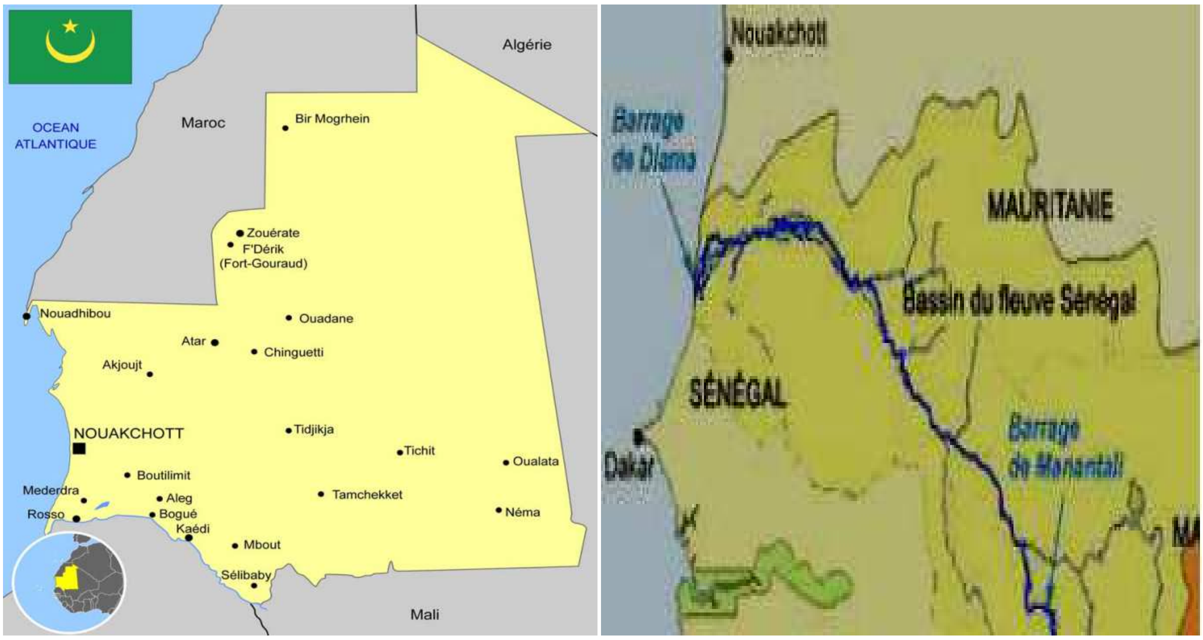

Fig. 1. The map of Mauritania, localization of Senegal River and Delta [10]

2.2 CHOICE OF THE SITES OF SAMPLINGS

To evaluate the quality of water of the Senegal River, one chose five sampling stations located on the axis of the river at the level of Rosso, Mauritania. These stations were selected according to their accessibility, their proximity of possible sources of pollution and their geographical distribution like continuation:

S1: It is the zone of agriculture located at the South-west of the town of Rosso, downstream from the city;

S2: This station named Satarat, located at 4 km of the East of the station of agriculture;

S3: The station of the transport (Bag) which is located at the South-west of Rosso between Mauritania and Senegal. The commercial exchanges of the inhabitants between the two countries are done by two types of transport: Bag and traditional transport by dugouts;

S4: It is the municipal zone of the slaughter-house of Rosso to 2 km east of Bag;

S5: N'dourbel, located downstream from the rejections of domestic waste waters to 3 km of the East of Bag represents a place of the discharge of waste waters.

Fig. 2. Localization of the sites of samplings [11].

3 EQUIPMENT AND METHODS

3.1 SAMPLING

The taking away of water of the Senegal River were carried out quarterly in January, May and September of the partner 2015in the zones where this water is not stagnant but running. These sampling were carried out in plastic bottles of 1Litre, clean, rinsed beforehand by the water of taking away, put at total immersion in water of the river and they are hermetically filled in order to avoid any contamination.

3.2 METHODS OF ANALYSIS

At the same time of the test sample selection of water, one proceeded to measure the temperature of water and the pH using a pH metre of type HANNA instrument HI 8314.Electric conductivity (C.E) was measured, using a conductimeter of the type HANNA instrument HI 8733.Nitrates (NO_3^-), nitrites (NO_2^-), the Ammonium (NH_4^+) and sulphates (SO_4^{2-}) are dosed by a UV-Visible Spectrophotometer (DR/5000).

Alkaline metals sodium (Na^+) and potassium (K^+) are dosed by photometer of flame. The alkaline title (TA), complete alkaline title (TAC), total hardness (HT) calcium (Ca^{2+}), magnesium (Mg^{2+}), Chloride (Cl^-), the carbon dioxide free (CO_2) and bicarbonates (HCO_3^-), are dosed by volumetric method Mohr in the presence of selective media [12]. The determination of the suspended matter undergoes the filtration of a water sample on a filter of Porosity (0, 45µm) [12].

4 RESULTS AND DISCUSSION

The physicochemical results which account for the 15samples taken from three seasons of the year 2015, namely the cold dry season, the dry hot season, and the raining season represented respectively by the months of January, May and September. The takings away are carried out in five sites of the study of the high delta of the Senegal River (Rosso, Mauritania).

These results are exploited by the descriptive statistical analysis in terms of analysis in principal components (ACP), which is a technique exploring.

Table 1: Descriptive statistics of the physicochemical parameters.

Variable	Observations	Minimum	Maximum	Average	Standard deviation
pH	15	6,5300	8,0000	7,1927	0,4145
T	15	26,0000	33,0000	28,6067	1,8394
EC (µs/cm)	15	46,0000	120,0000	77,3333	20,2261
HT (°F)	15	4,0000	84,0000	27,8400	19,3384
Ca^{2+} (mg/l)	15	3,1250	10,6000	6,6931	2,6425
Mg^{2+} (mg/l)	15	0,5400	14,0900	3,3245	3,3053
Na^+(mg/l)	15	4,0000	21,0000	7,5333	4,0685
K^+(mg/l)	15	1,0000	10,0000	3,5333	3,4198
NH_4^+(mg/l)	15	0,0000	1,3500	0,3823	0,4867
NO_3^-(mg/l)	15	0,0000	4,9000	1,1993	1,7788
NO_2^-(mg/l)	15	0,0000	1,2300	0,2653	0,4317
SO_4^{2-}(mg/l)	15	0,0000	4,8900	0,8813	1,4610
HCO_3^-(mg/l)	15	18,3000	61,0000	36,1467	12,3263
CL^-(mg/l)	15	6,4800	88,7500	27,3120	25,1883
CO_2 (mg/l)	15	6,9470	28,4500	17,2674	6,4545
TA (mg/l)	15	0,0000	0,0000	0,0000	0,0000
TAC (mg/l)	15	1,0000	6,0000	2,8733	1,4280
MES (mg/l)	15	0,0000	35,1040	7,3609	16,63

The pH varies between 6,5-8,00 and conductivity varies between 46-120 us/cm which are in conformity with the European standards of potabilities of water, the values of the pH show that the water is favorable to irrigation. We note that the water of the river is not very mineral-bearing because of the concentrations of the elements salts such as Ca^{2+}, Mg^{2+}, Na^+ and K^+ which is in conformity with the standards. The concentrations of NO_3^-(0-4,9mg/l), Cl^- (6,4-88,75 mg/l) and sulphates SO_4^- (0-4,8 mg/l) remain in conformity with the standards. On the other hand, the concentrations of the NH4+ oscillates between 0-1,35 mg/l, NO2- varies between 0 - 1.23 mg/l, HCO3- varies between 18 and 61mg/l and CO2 vary between 6.94 and 28.45 mg/l-respectively exceed the standards 0,5mg/, 0,1mg/l, l30 mg/l and 10 mg/l.

4.1 APPLICATION OF THE ANALYSIS IN PRINCIPAL COMPONENTS

The ACP allows in particular the description of association between variables. Therefore, it reduces the dimensioning of the table of the data. That is achieved by the diagonalisation of the matrix of correlation of the data which transforms a large number of variables into a more small number of subjacent factors without losing much information [13]; [14]; [15].

Table 2: Eigenvalues of the factors of the ACP

	F1	F2
Eigenvalues	7,3253	3,2047
Variability(%)	43,0898	18,8513
% cumulated	43,0898	61,9411

The principal components present inertia of 61.94(Table 2, Figure 3) composed of the variability of the axis F1 of 43, 09% added to that of the axis F2 with 18, 85%, which is significant for the feasibility of this exploratory descriptive analysis (ACP).Under figure 3, we have a cumulated percentage of 61, 94% which presents the two axes F1 and F2 with a good representation of the variables on the circle of correlation (Figure 4).

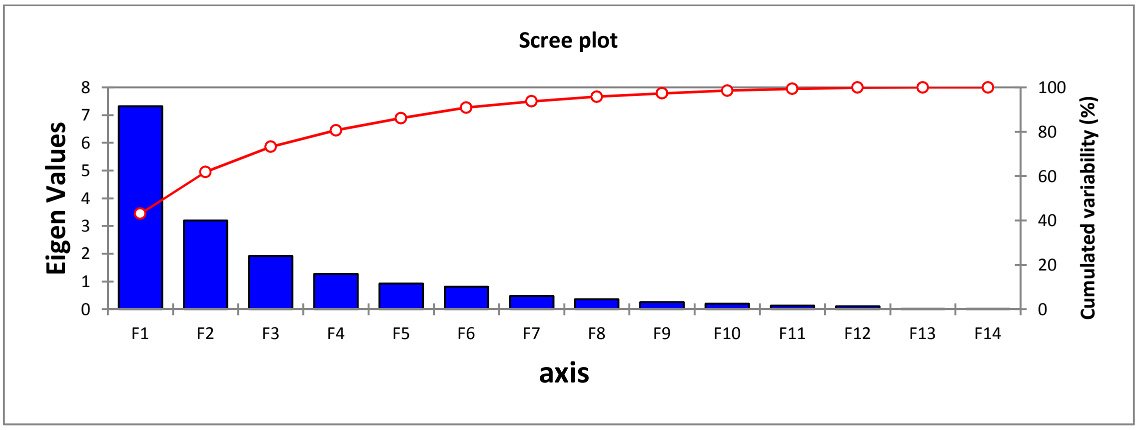

Fig. 3. Presentation of the eigenvalues and cumulated variability (%).

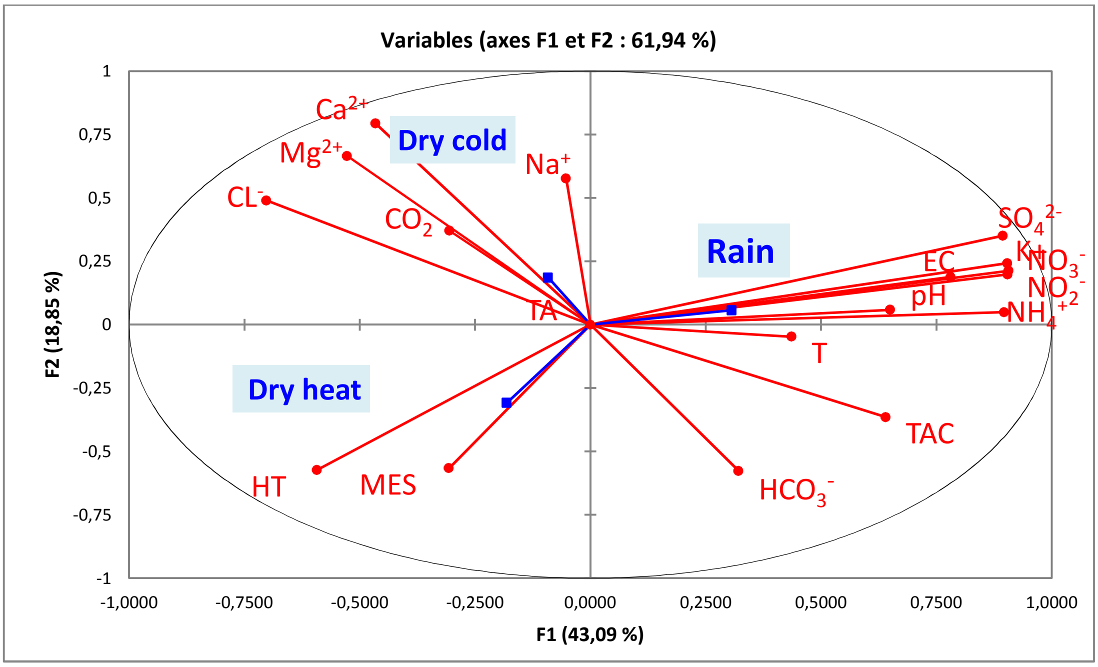

Fig. 4. Projection of the variables on the factorial design F1 X F2 (61, 94%)

The factorial design, variables NH_4^+, SO_4^{2-}, NO_2^-, NO_3^-, TAC, pH, K^+, electric conductivity are correlated positively on the axis F1on the other HT and $Cl^-$are correlated negatively on the axis F1.Conversely, the mineral matter in terms of Na^+, Ca^{2+}, Mg^{2+} are correlated positively on the axis F2 on the other hand the HCO_3^- and suspended matter which are correlated negatively on the axis F2.

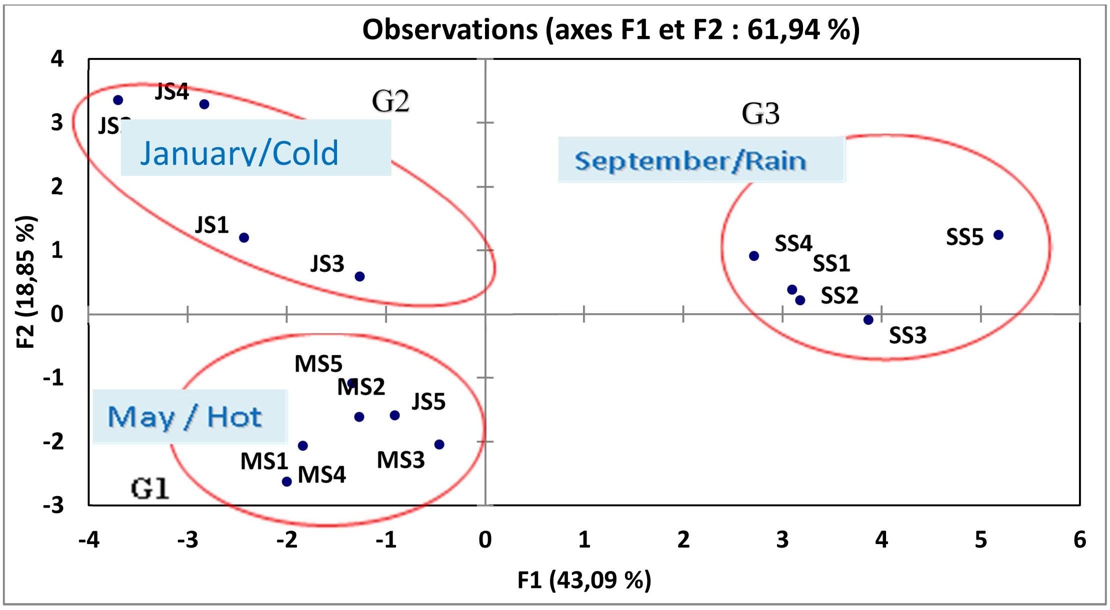

Fig. 5.   Projection of the individuals on the factorial design F1 X F2 (61, 94%)

The factorial projection of the individuals gave us a regrouping according to the seasons represented by the significant months of each season. The sites are gathered in groups: G1, G2 and G3 according to their resemblance and similarity of water quality.

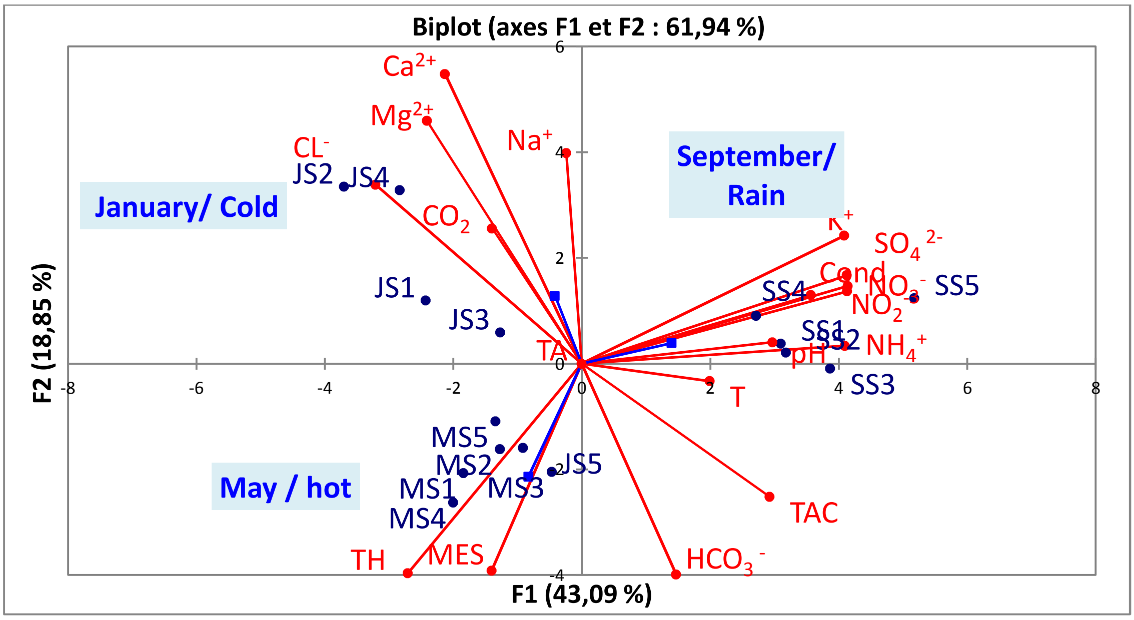

Fig. 6.   Projection of the variables and the individuals on the factorial design F1 X F2 (61, 94%)

We have a distribution of the variables studied and sites of the taking away according to a gradient which follows the effects of the seasons initially represented by the month of January which witnesses a dry cold climate or there is a fresh water of low temperature with concentrations considerable in Ca2+, Mg2+, Cl-, CO2 and Na+. They vary from asite to another (JS1 JS2 JS3 and JS4) while decreasing from left to right with the increase in the temperature, Pass the month May which represents the hot and dry period. There is no a material impact on water quality except an increase in MES and water becomes harder with sites (MS1, MS2, MS3, MS4, MS5 and JS5). Around the raining season which is considered the hottest period one Mauritania. At this period one observes a complete inversion of quality by the presence of elements such as NO3-, NO2-, NH4+ and SO42- with concentrations raised in sites (SS1 SS2 SS3 SS4 SS5) on the axis F1 as a consequence of transport of waste and other towards the river by rainwater. These concentrations are decreasing by the right-hand side towards the left of characterized projection factorial the months respectively hot and cold May and January.

5 CONCLUSION

Following the example of results physicochemical of the high delta of the Senegal River (City of Rosso), one can deduces that the quality of the water is generally acceptable with elements exceeding the European standards of the potability of water such as bicarbonates, nitrates, Ammonium and the dioxide of carbon. These spades can be explained by the human activities in the zones like agriculture, the rejections of domestic wastewaters and slaughter by the bank of the river, which requires control of hygiene by the authorities concerned.

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