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Point position of the Bacteriological Physicochemical Quality and Wetlands Water Mapping of Guerbes-Sanhadja eco-complex (Skikda, Northeastern Algeria)

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ABSTRACT: The Algerian Numidia (North-East of Algeria) is composed of twenty freshwater bodies, most of which are marshy and enclosed in forested areas, some of them such as (Lake Tonga, Garaet Hadj-Tahar ....) have a legal protection (Ramsar site). They are rich in aquatic herbarium and attract a wide variety of aquatic birds. They have also the ability to store and restore progressively large amounts of water and allow the supply of groundwater and surface water.The ecological balance of these aquatic ecosystems is threatened by the impact of several factors such as unfavorable climatic changes and anthropogenic impact. In fact, discharges of domestic wastewater, directly, and without any prior treatment in certain water bodies, are the main causes of the ecological imbalance, which have adverse consequences on the environmental, agricultural, economic and health levels.In order to make an assessment of the bacteriological and physicochemical quality of the water of these hydro-systems, we have chosen 6 marshes of this complex: Garaet Beni M'hamed, Garaet Lemsaouessa, Garaet Chichaya, Garaet Sidi Makhlouf, Garaet Hadj Tahar and Garaet Sidi Magroun. For each site we have selected two sampling points.According to the results of the bacteriological and physicochemical analyzes, we found that all the water samples studied had a fair to good quality with minimal contamination at the exception of Garaet Lemsaouessa and Garaet Chichaya. The latter were characterized by the presence of germs, especially indicators of faecal contamination.

KEYWORDS: Guerbes-Sanhadja eco-complex, wetland, bacteriological characteristics, physicochemical characteristics, Algeria.

1 INTRODUCTION

Wetlands are among the most productive and richest diversity areas in the world. They represent a life place for many animal species such as fish, batrachians and some mammals. They host frequently birds as they represent shelters to some unique plants, allowing these ecosystems to play an important role in maintaining the balance in biodiversity as well as water on the planet (Metallaoui, 2010).

The Mediterranean area is bordered by a string of wetlands, which constitute an exceptional floristic and faunistic richness. Moreover, Western Numidia (northeastern of Algeria), represented by the Guerbes-Sanhadja Ramsar site since 2001(Boumezbeur, 2001), contains 31 wet sites (Samraoui and De Belair, 1997). These sites play an important role for the wintering aquatic avifauna and receives every year about fifty species of water birds (Metallaoui and Houhamdi, 2008). It is also a breeding ground for the migratory avifauna, including species classified as threatened with extinction (Bird Life International, 2004).

The determination of the structure and the composition of an aquatic ecosystem are often a good indicator for the state of health of an environment and (and even the biotope) the entire biotope (Delarras, 2007). For these hydro-systems, this can be estimated through the study of the quality of its waters. This assessment of surface water quality is based as much on the (monitoring of) measurement of physicochemical and microbiological parameters.

The aim of this work is to determine and cartography physicochemical and bacteriological quality of water of Guerbes-Sanhadja wetlands.

2 Materials And Methods

2.1 Study area

The eco-complex Guerbes-Sanhadja is a large coastal plain in northeastern of Algeria with a superficies of 42,100 ha (Fig.01). It contains sites of international importance that provide representative, rare and/or unique examples of natural wetland type whether for the Maghreb, North Africa, North-Central African sub-region or even the Mediterranean region. The Guerbes-Sanhadja complex is particularly valuable for the maintenance of biodiversity (Samraoui and De Belair 1998, Metallaoui and Houhamdi 2008). It was included in the Ramsar List of Wetlands of International Importance in 2001 (Boumezbeur, 2001). The western complex is bordered by the coastal hills of Skikda and eastern side by the Chetaïbi coastal forest. The zone altitudes are between 0 and 200 meters.

The main lithological units consist mainly of wind and alluvial deposits. The notable character of the flora and fauna of this region originates from: geomorphological diversity, and its location at a bioclimatic junction, resulting in a high biodiversity richness (Boumezbeur, 2001).

The massif continental dune of Guerbes plain is a water reservoir of about 40 million m^3 which generates a multitude of depressions and valleys forming lakes and garaet (Joleaud, 1936), from a few hectares of surface to several tens of hectares. The eastern and southern side of Oued El Kebir massif and its tributaries with many meanders due to the low slope feed a series of collections of natural or artificial waters (small dams or reservoirs). The dune-alluvial plains contact has formed moist forests (alder groves) of up to 180 ha. Most of these environments have an acid or neutral pH soil that develops very frequently on peat, the main wetlands of this ecosystem are: Garaet Beni M'hamed, Garaet Lemsaouessa, Garaet Moussissi, Garaet Elhouas, Garaet Hadj-Tahar, Garaet Dahria and Garaet Boumaiza ... (Fig.01) (Atoussi, 2008).

2.2 Methods

2.2.1 Physicochemical and bacteriological characterization of the biotope

Sampling points

Two essential factors have been taken into account in the choice of sampling points. The first is that the Guerbes-Sanhadja complex is characterized by the large area of its wetlands. The second is the distribution of chemical elements and microorganisms in surface waters.

As a result, we selected two sampling points for each wetland. The location of each sampling point is defined using a GPRS device, as summarized in Table 01.

Table 1. Characteristics of sampling points

Station		Geological coordinates			Distance to the bank	Depth
		x	y	z		
Beni M'Hamed	1	36°57'35,94'' N	7°17'07,65'' E	2 m	30m	25 cm
	2	36°57'35,17'' N	7°16'56,95'' E	3m	24 m	27 cm
Lemsaouessa	3	36°56'20,09'' N	7°5'27,49'' E	3 m	59 m	33 cm
	4	36°56'35,23'' N	7°15'26,47'' E	4 m	12 m	42 cm
Chichaya	5	36°53'48,34'' N	7°18'08,87'' E	10 m	1,5 m	110 cm
	6	36°53'47,82'' N	7°18'12 ,18'' E	11 m	10 m	70 cm
Sidi Makhlouf	7	36°53'06,45'' N	7°18° 18,67'' E	14 m	3 m	105 cm
	8	36°53'03,88'' N	7°18' 20,02'' E	14 m	7 m	87 cm
Hadj Tahar	9	36°51'46,23'' N	7°15'25,65'' E	13 m	8 m	69 cm
	10	36°51'42,09'' N	7° 15'52,18'' E	11 m	13 m	73 cm
Sidi Magroun	11	36°50'15,01'' N	7° 16'50,02'' E	19 m	4,5 m	59 cm
	12	36°50'15,50'' N	7° 16'56,96'' E	18 m	3 m	71 cm

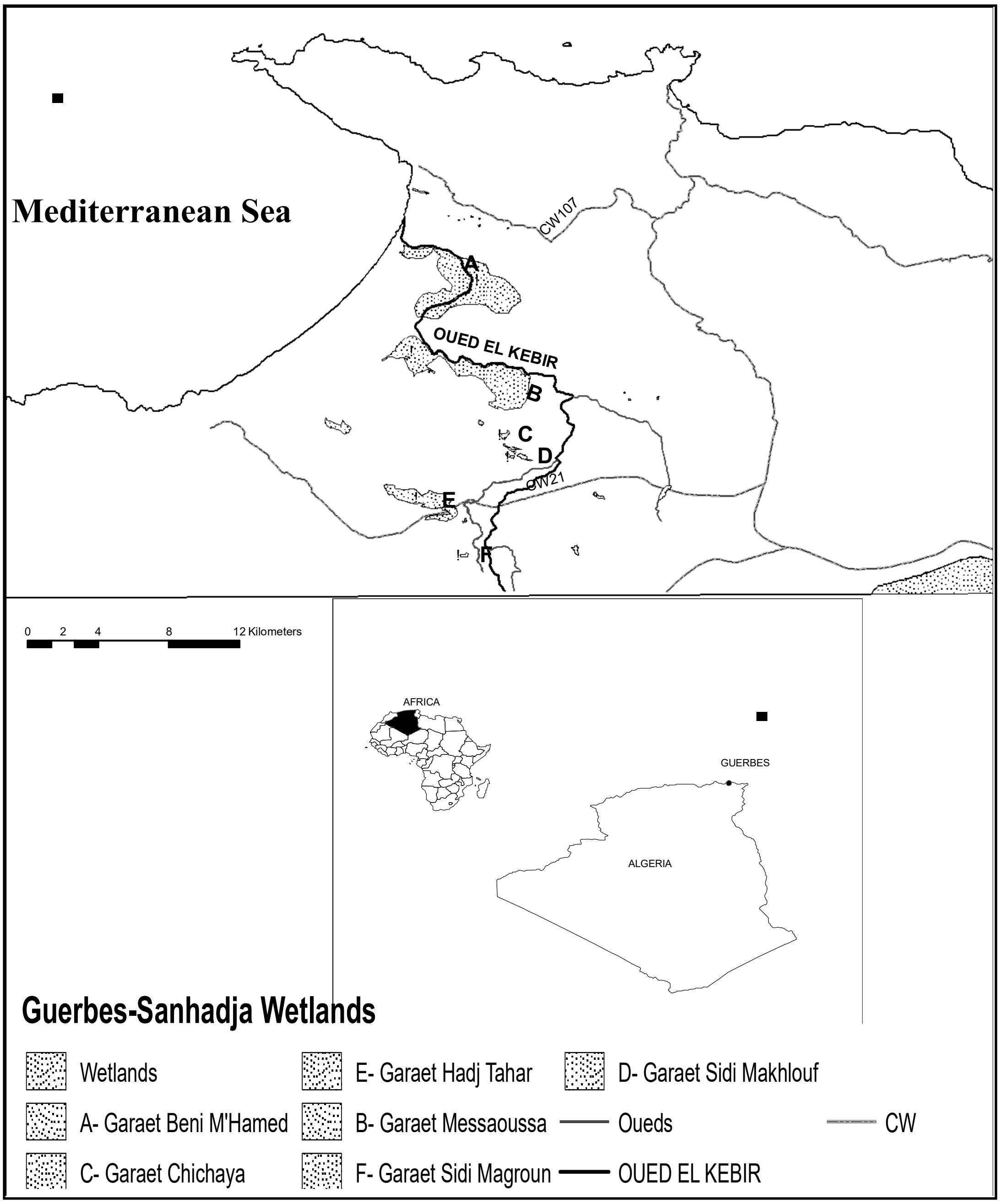


Fig. 1. Location of main wetlands of the Guerbes-Sanhadja complex

Sampling and analyzes

Water samples were collected during 04 campaigns (seasonal sampling) at a different depth following wetlands (Tab.01). However they must be far from the bank as recommended by Rodier *et al.* (2009).

For bacteriological analyzes, samples were collected using sterile techniques. Samples are tagged and transported in an isothermal box (4-6ºC) to laboratory. In our study and for the evaluation of germs responsible for fecal contamination (total coliforms, faecal coliforms, and faecal streptococci), we used the liquid seeding or Most Probable Number (MPN) method is most commonly used for murky waters (Tandia, 2007).

Concerning physicochemical analyzes, sampling was carried out according to Rodier's (1984) protocol and recommendations

For every single sample collection, *in situ* measurements were performed to determine certain environmental characteristics such as temperature, pH, conductivity and dissolved O_2. These parameters are very sensitive to environmental conditions, they can disappear or change during storage and transport of the sample to the laboratory (Rodier *et al.*, 1996). These parameters were measured in situ using a multiparameter field (Inolab 750wtw).

Concerning the other parameters (NO_3, NO_2, PO_4), the measurements were carried out at the laboratory according to spectrophotometric methods standard with the following references, nitrates: ISO 13395: 1996, nitrites: ISO 6777: 1984 and orthophosphates: NF EN 1189.

2.2.2 STATISTICAL ANALYZES

Statistical analyses were performed using the XLSTAT (XlStat-Pro. V.7.5.2) software, including Principal Component Analysis (PCA) and Pearson matrix correlation test, to check the dependencies of studied parameters.

2.2.3 GEOGRAPHIC DISTRIBUTION

Spatio-temporal distribution patterns of the elements were determined in all wetlands, and mapped with Arc GIS 9.3 version.

3 RESULTS AND DISCUSSION

3.1 PHYSICOCHEMICAL CHARACTERISTICS OF WATER

THE PH

For this parameter, we noticed that there was no great variation between the sampling points with a an average of 7,63. We recorded a pH of 7 at Garaet Chichaya, Garaet Hadj-Tahar, Garaet Sidi Magroun and 8,5 at P3 at Garaet Lemsaouessa (Fig.02).

According to W.H.O. (2000) the pH of surface water must be between 6,5 and 8,5. As a result, we can deduce that the quality of our water is good (pH 6,5 to 8,5) according to the water quality assessment scale (MEDD and Water Agencies, 2003).

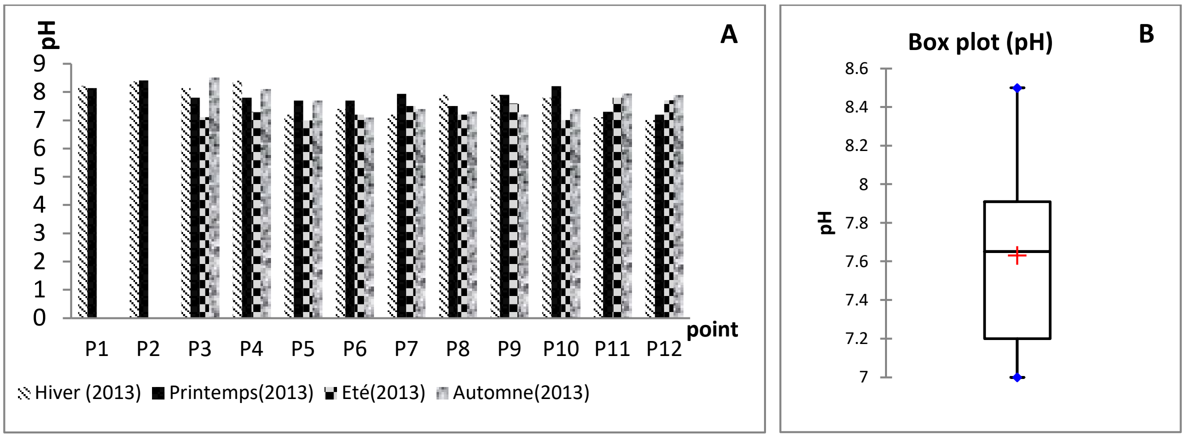


Fig. 2. Spatio-temporal variations of pH values in main wetlands water of Guerbes-Sanhadja complex

Similar results were found by Merzoug (2010) where pH values range from 6,64 to 7,95. Our results are also consistent with surface water studies in sub-Saharan Africa: Chapman and Kimstach (1996) and Aguiza *et al.* (2014) found pH values ranging between 6 and 8,5. On the other hand, Ramdani and Laifa (2017) studied Oued Bounamoussa and recorded significant variations in pH between 5,94 and 8,26. In Mauritania, Hasni *et al.* (2018) reported values between 7,5 and 9.

TEMPERATURE

Water temperatures recorded in our study oscillate between 12,5° C during the cold months and 27,1° C during the high temperature months (Fig.03), these temporal variations indicated the influence of seasonal climatic variations.

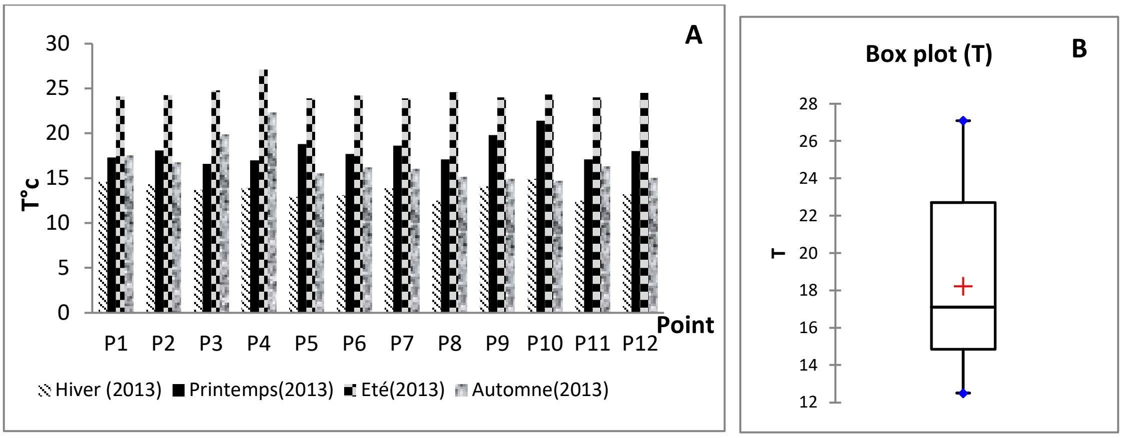


Fig. 3. Spatio-temporal variations of temperature values in main wetlands water of Guerbes-Sanhadja complex

Spatial variations of temperatures are noted, we recorded very high values for P4 comparing to the other studied points, especially during the high temperature period (Fig.03).

The thermal gap between these stations is due to the release of urban wastewater discharges from the inhabitants in the vicinity of P4 which causes a remarkable increase in water temperature compared to other points.

Several authors, particularly in North Africa, have studied the physico-chemical parameters of surface water, and have recorded widely varying values. According to the results of Merzoug (2010), the water temperature of Garaet Hadj Taher varies from 9,6° C to 25° C. In the same region of eastern Algeria and in nearby of Oued Bounamoussa, Ramdani and Laifa (2017) reported an interval of 11° C to 33° C. Thus Djouamaa (2011) has shown that the water temperature of a wetland at ElOued has high values ranging between 20° C and 35° C. Djemai (2008) recorded temperatures of 8 to 10° C by analyzing the surface waters of the Oued Sébaou Valley in Algeria. Other surface water analyzes in Morocco recorded temperatures ranging from 8,6 to 17° C (Abboudi *et al.*, 2014), while in the sub-Saharan country in southern Mauritania, Zinsou et al. (2016) in Benin, relatively high values of 22 to 30,5° C, when, in Cameroon, the average surface water temperature is 25° C (Aguiza *et al.*, 2014).

ELECTRICAL CONDUCTIVITY (EC)

The values of the electrical conductivity show very significant spatio-temporal variations. The highest values are recorded at points P1 and P2 (Garaet Beni M'Hamed), especially during the period of high temperature showing very high mineralization, these values oscillate between 416 µS/cm and 1372 µS/cm (Fig.04A). The low recorded values characterize mainly the winter period, they oscillate between 255 µS/cm and 1020 µS/cm (Fig.04B).

Several factors can be the cause of the high values of the electrical conductivity. The increase of the temperature that causes the evaporation of the water concentrating the dissolved salts, and the feeding of these sites by the waters of the Oued El- Kebir constitute a continuous external contribution in mineral salts as the waters come back from the Sea a little saltier.

In addition to the two previous factors, the electrical conductivity varies as well according to the crossed geological substrate since this site is close to the mouth of the Marsa where the the ground is more and more sandy.

On the other hand, the decrease of the electrical conductivity during the rainy periods can concord with the phenomenon of dilution.

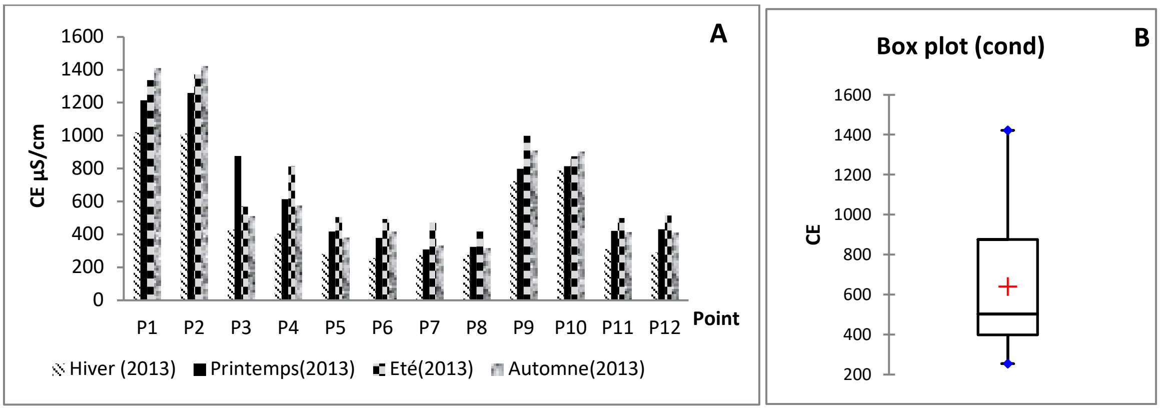


Fig. 4. Spatio-temporal variations of the conductivity values in main wetlands water of Guerbes-Sanhadja complex

Our results are comparable with those found in sub-Saharan Africa: Kambiré *et al.* (2014) pointed out that the conductivity measured in the Aby Lagoon, Ivory Coast, shows values between 800 µs/cm and 2400 µs/cm. Thus, in the study of Hasni *et al.* (2018) carried out in Mauritania, the values ranged between 99,5 µs/cm to 750 µs/cm.

DISSOLVED OXYGEN (DO)

The oxygen levels determined during the study period show remarkable temporal and spatial variations. We noted that the rates obtained for dissolved oxygen at P4 are the lowest, with a minimum of 1,1 mg/l, whereas the values recorded at P8, P9 and P10 are marked by high peaks with a maximum of 8,9 mg/l (Fig.05A).

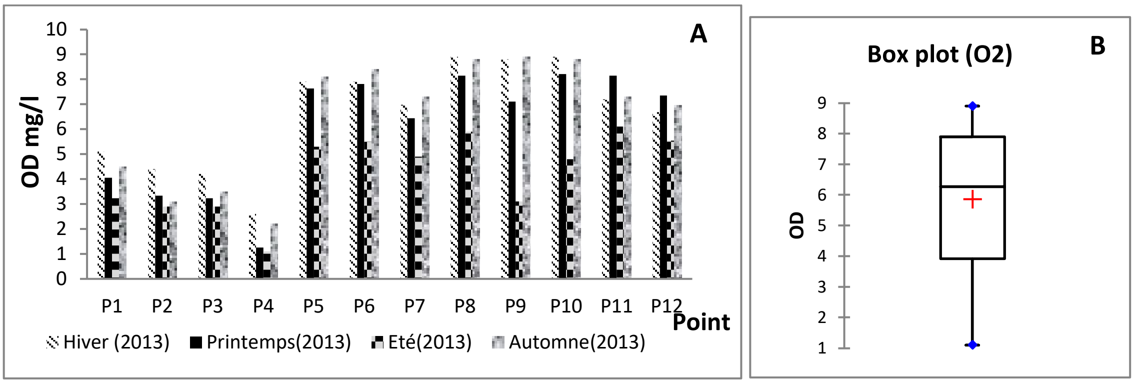


Fig. 5. Spatio-temporal variations of OD values Guerbes-Sanhadja wetlands water

These wetlands are slightly oxygenated, especially during the summer. The increase and decrease of the oxygen level at these water is directly related to the values of the temperatures as well as the quantity of the organic matter. So, the increase of the temperature of the water and the decomposition of large quantities of organic matter, which generally come from animals and domestic discharges, causing the decrease of the dissolved oxygen level and vice versa.

These results are consistent with Kouti *et al.*'s (2016) at the wetland complex, they ranged from 5,1 mg/l to 7,8 mg/l. Merzoug (2010) recorded values between 2,8 mg/l and 9,4 mg/l at Garaet Hadj-Taher. Other investigators reported lower values of 3,18 mg/l to 6,19 mg/l in Benin by Zinsou et al. (2016) and 1,1 mg/l to 4,5 mg/l.

NITRATES (NO3)

In our study, nitrate levels vary from one point to another and from one season to another. We recorded high rates during the summer season, with a maximum of 3,47 mg/l recorded at P4, while the low values characterized the rainy season with a minimum of 0,13 mg/l in P5 (Fig.06A).

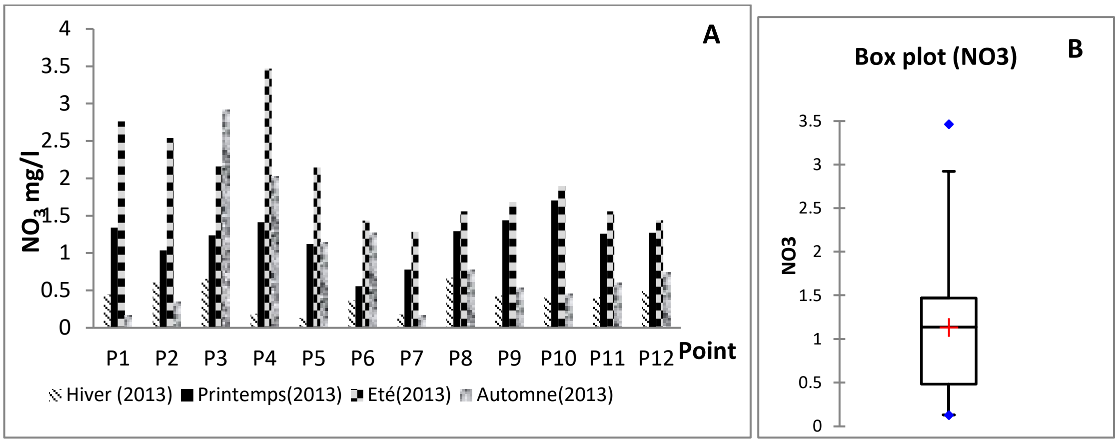


Fig. 6. Spatio-temporal variations of NO_3 values in Guerbes-Sanhadja wetlands water

The high values of nitrates in the summer season compared to the rainy season, noted in P3 and P4, could be due mainly to the intense evaporation and augmentation of the degradation of organic matter. Besides, the pollutant load resulting from the discharge of habitats wastewater is located in the vicinity of this site (Garaet Lemsaouessa). As for the values recorded during the rainy season, they are due to the agricultural practices consisting in applying abundantly industrial fertilizers or manure. The use of chemical fertilizers and organic (fertilizer) to amend the soil enriches the fields in nitrogen and under the effect of rain; this nitrogen is leached to these water bodies increasing its content.

The findings of NO_3 levels analyzes reported by Kouati *et al.* (2016) showed values closer to our results ranging between 0,044 mg/l and 3,987 mg/l, whereas Merzoug (2010) recorded more or less low values, ranging from 0,007 mg/l to 0,092 mg/l. On the other hand, other studies have shown high values of nitrate levels in surface waters, Khadri (2009) at Oued Seybouse noted values ranging between 0,570 mg/l and 7,093 mg/l.

NITRITES (NO2)

Our results show that nitrite levels follow a seasonal rhythm equivalent to that of nitrate. We noted remarkable levels in periods of high temperatures, the values were about 0,70 mg/l recorded in P4, while the low levels were recorded in winter periods in P1 is 0,026 mg/l (Fig.07A).

This element may be toxic at these exaggerated concentrations (average of 0,40 mg/l) exceeding the standard (0,184 mg/l) (Aounallah, 2007). Changes in NO_2 concentrations are due to the same factors such as wastewater discharges and climatic factors affecting the NO_3 concentrations.

Our findings recorded at the different water levels of the Guerbes-Sanhadja wetlands complex are partially similar to those recorded in other works: 0,001 mg/l-0,092 mg/l noted by Merzoug (2010) and 0,0008 mg/l-0,0038 mg/l noted by Kouti *et al.* (2016) in the same region.

A

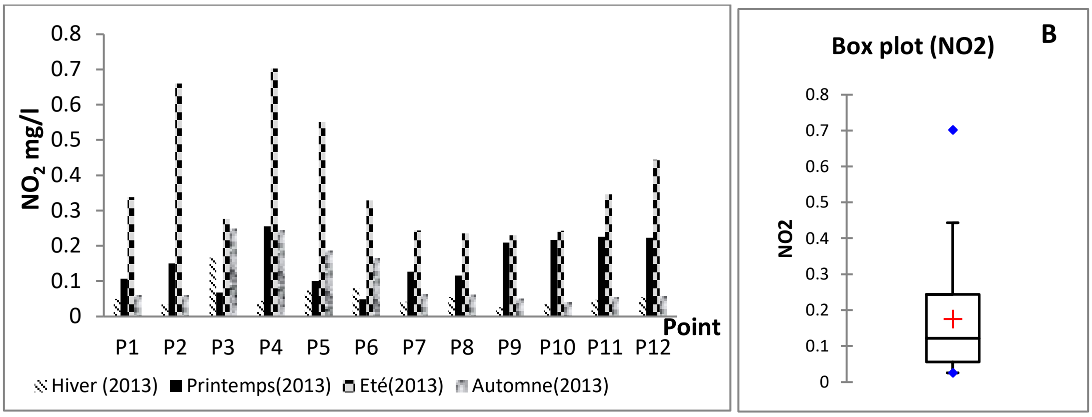


Fig. 7. Spatio-temporal variations of NO_2 values in Guerbes-Sanhadja wetlands water complex

PHOSPHORUS (PO_4)

the levels of phosphates in the water of the Guerbes-Sanhadja complex wetlands show significant fluctuations (Fig.08A) marked by a peak of 0.28 mg / l observed during the summer period in P3, with a highest concentrations in P3 and P4 compared to other points where we have recorded the lowest concentrations during the winter period with a peak of 0.007 recorded at P7 (Fig.08A).

The presence of phosphates in natural waters at concentrations higher than 0,2 mg/l is indicative of pollution by valve waters containing organic phosphates and synthetic detergents as well as runoff water (Mehennaoui, 1998).

Our results are consistent with those of Merzoug (2010), where he has recorded values ranging between 0,004 mg/l and 0,21 mg/l.

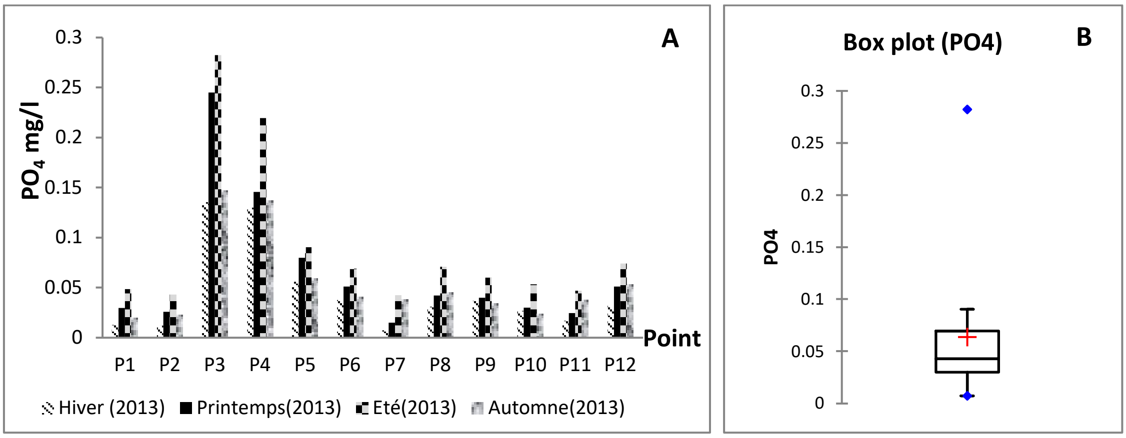


Fig. 8. Spatio-temporal variations of PO_4 values inGuerbes-Sanhadja wetlands water complex

3.2 BACTERIOLOGICAL QUALITY OF WATER

TOTAL COLIFORMS

Our analyzes show that the number of total coliforms is very high during the dry period (Fig.09). The average concentration is of the order of $11*10^4$ germs/ml. The maximum concentration was recorded at P4 with more than $2*10^6$ germs/ml, while the minimum concentration was obtained at P1 with $12*10^2$ germs/ml (Fig.09A).

A

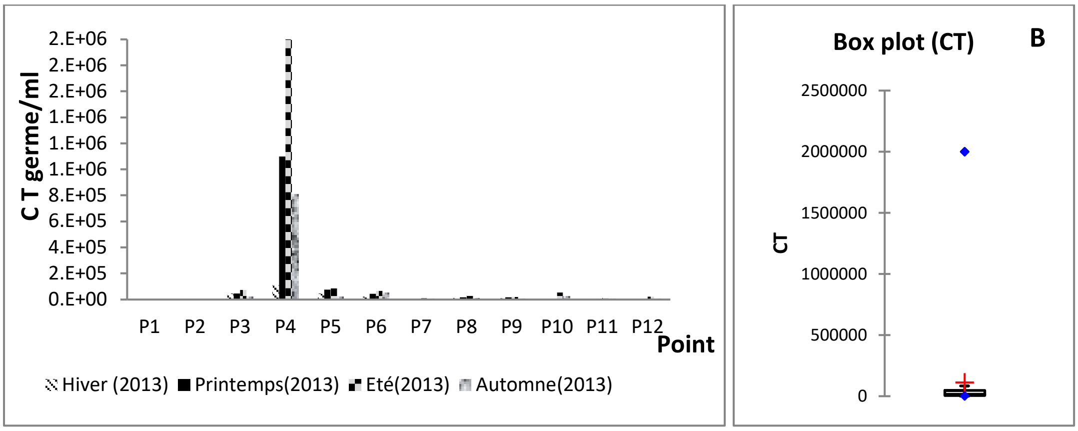


Fig. 9. Evolution of the number of total coliforms in Guerbes-Sanhadja wetlands water complex

The observation of the results of the fecal coliform count obtained revealed significant seasonal and spatial variations, where the minimum concentrations are recorded during the winter period, while the maximum concentrations are recorded during the summer period.

Our results are identical to those highlighted by Merzoug (2010) and Koutiv *et al.* (2016) in the same region.

FECAL COLIFORMS

The enumeration of fecal coliforms in the water of the Guerbes-Sanhadja complex show that this water contains an average concentration of $41*10^3$germs/ml. The maximum concentration was recorded at P4 with $11*10^5$germs/ml, while the minimum concentration is obtained at P1 with 850 germs/ml (Fig.10A).

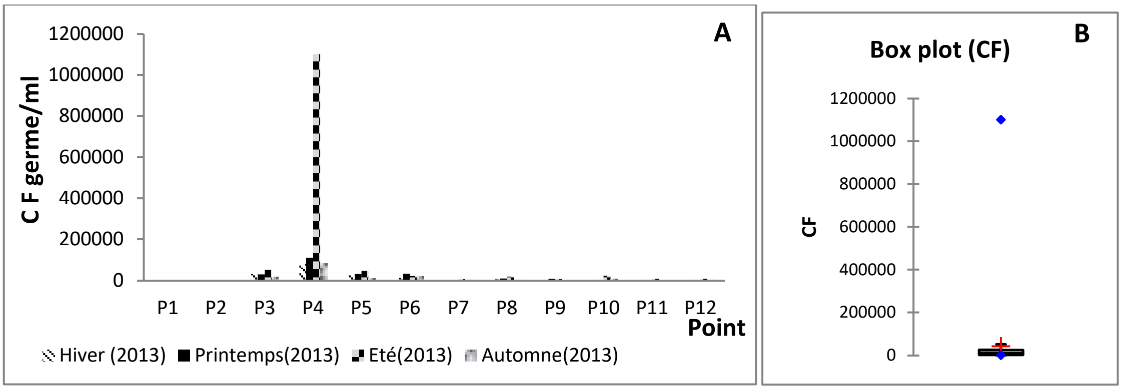


Fig. 10. Evolution of the number of fecal coliforms in Guerbes-Sanhadja wetlands water complex

The summer period is characterized by high concentrations, while the winter period is characterized by low concentrations (Fig.10A).

Our results are consistent with those of Merzoug (2010) and Kouti *et al.*(2016) made in the same region.

FECAL STREPTOCOCCI

As for fecal streptococci, it is noted that their average concentration in wetlands water of Guerbes-Sanhadja complex is of $16*10^3$germs/ml, with a maximum value recorded at point P4 ($81*10^3$germs/ml) and a minimum value recorded at points P1 and P2 (respectively $8{,}5*10^2$ and $9*10^2$germs/ml) (Fig.11A).

Furthermore, our findings show that the number of fecal streptococci in the water of these wetlands undergoes large fluctuations during the study period. The minimum concentrations are recorded during the winter period, while the maximum concentrations are recorded during the summer (Fig.11A).

The findings of Merzoug (2010) and Kouati *et al*. (2016) in the same region are similar to ours.

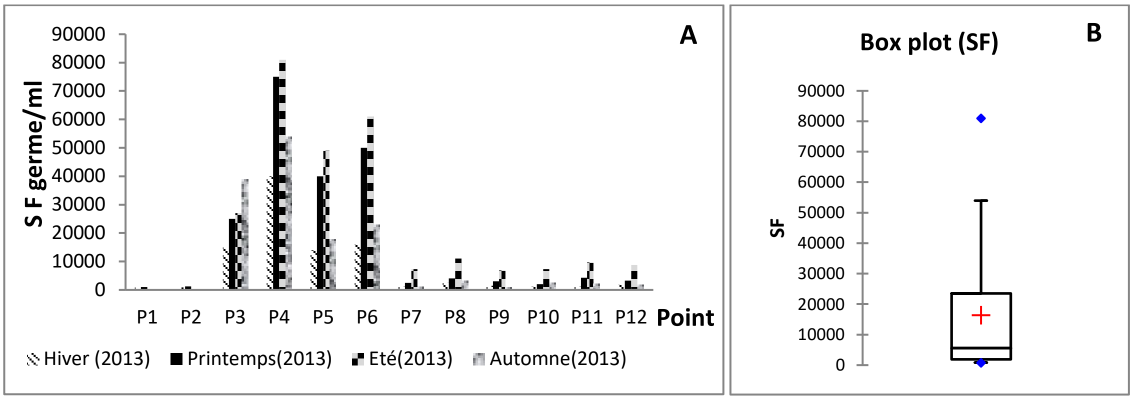


Fig. 11. Evolution of the number of fecal streptococci in Guerbes-Sanhadja wetlands water complex

Bacterial enumeration results show values above the allowable standards. Several factors could explain these high rates. Indeed, the large spatial variations of the bacterial load and the indicator flora of fecal contamination seem to be related to the water flow and the effect of the few domestic discharges and livestock and the use of manure as fertilizer (over 49,000 cattle and sheep grazing extensively) (D.G.F., 2002), which explains the high concentrations of bacteria recorded in P4 (GaraetLemsaouessa), in additionit is fed by the waters of Oued El-Kebir, which plays a role in the transmission of pollutants and other substances that lead to the proliferation of these germs.

Concerning the temporal variations of the recorded values, they can be explained by the influence of the hydrometeorological conditions changes. Temperature and precipitation have the most important role in decreasing and/or increasing the conditions of development and bacterial growth.

PRINCIPAL COMPONENT ANALYSIS (PCA)

In order to establish a relationship between the different physicochemical and bacteriological parameters and for a better evaluation of the effect of anthropogenic activities on the water quality of the Guerbers-Senhadja wetland, we performed a statistical treatment to set parameters. Our ACP analysis was conducted with a matrix of 12 sampling points and 10 descriptors.

Table 02 and Figure 12 give respectively the correlations between variables, factors, and the projection of the variables in the space of the axes F1 and F2.

Table 2. Correlation Between Variables and Factors

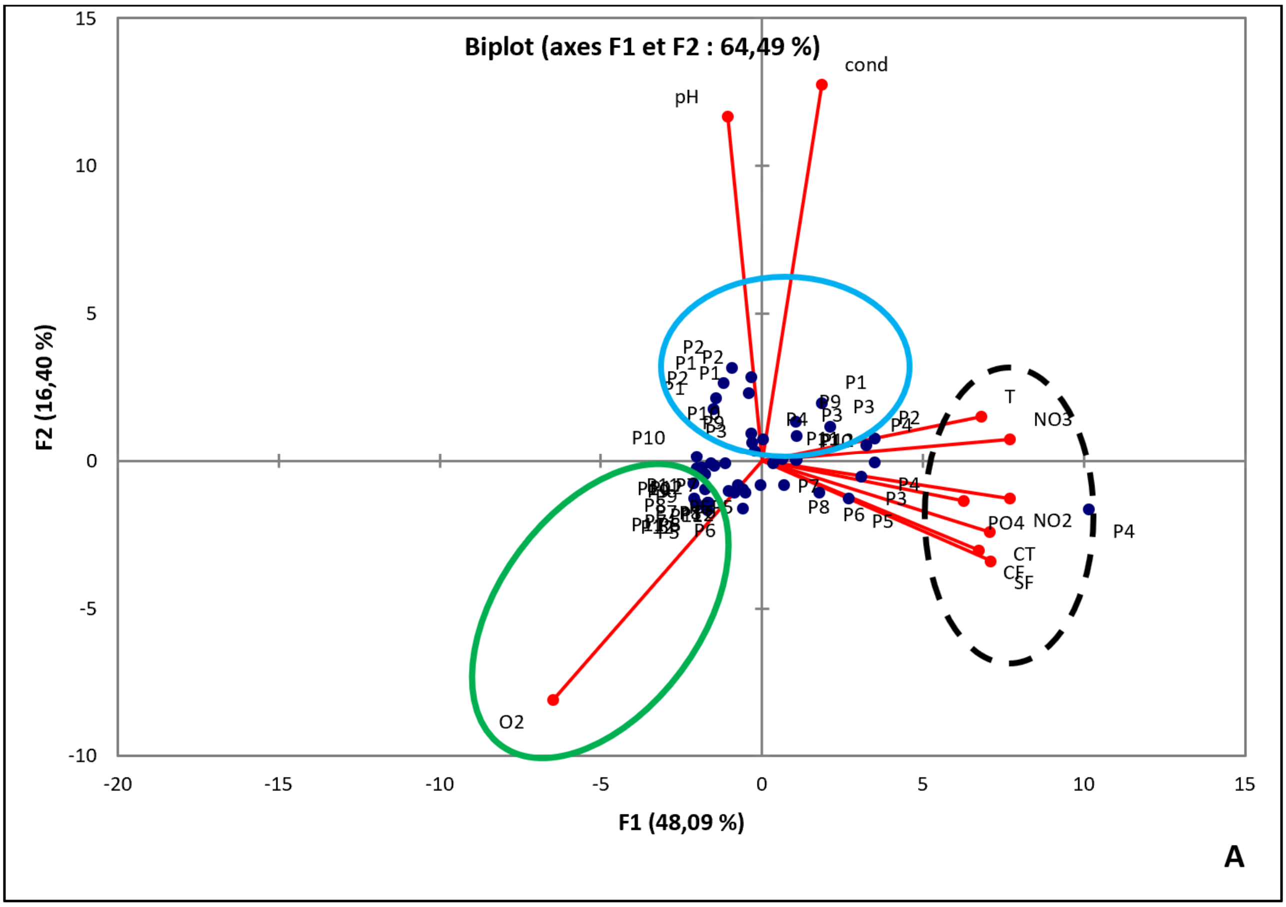
	F1	F2
pH	-0,118	0,750
T	0,750	0,098
EC	0,203	0,819
DO_2	-0,714	-0,521
NO_3	0,847	0,049
NO_2	0,845	-0,081
PO_4	0,691	-0,088
TC	0,779	-0,155
FC	0,744	-0,196
FS	0,782	-0,217

The analysis of the factorial plan F1 and F2 shows that more than 64,49% of the observations are expressed. Axis F1 has a variance of 48,09% and is expressed by CT, CF, SF PO_4, NO_2, NO_3 and T ° (Tab.02 and Fig.12). Axis F2 has a variance of 16,40% and is expressed by: the electrical conductivity, pH and dissolved O_2 (Tab.02 and Fig.12).

It is noted that F2 axis opposes clearly the sites where concentrations of fecal germs and nutrients are very high compared to those with low concentrations of dissolved O_2, they are mainly noticeable during the summer. This allows us to distinguish that the increase in nutrient levels (degradation of organic matter) is always accompanied by the presence of large masses of microorganisms under the effect of high temperatures noted especially in points P3 and P4. This phenomenon causes a decrease in the concentrations of dissolved O_2 in these points during this season. Conversely, the points where we recorded high concentrations of dissolved O_2 are characterized by low concentrations of mineral salts and low microbial masses (P9, P10-Guerat Hadj-Taher and P7, P8-Garaet Sidi Makhlouf).

A third group opposes the two previous ones where the waters are less rich in indicator germs of fecal contamination in whiche pH values are high, it means that these waters are less polluting compared to the others, this is noticed especially during the winter period (P1, P2 – Beni M'Hamed Garaet)

PCA has shown that the pollution with the indicator of fecal contamination is represented along of F2 axis (Fig.12). This pollution is rather anthropogenic and would result from the presence of domestic waste and excrement of animals at the edge of these wetlands, it is also noted that the use of fertilizers and pesticides in agriculture contributes to the increase of the concentrations of certain chemical elements.



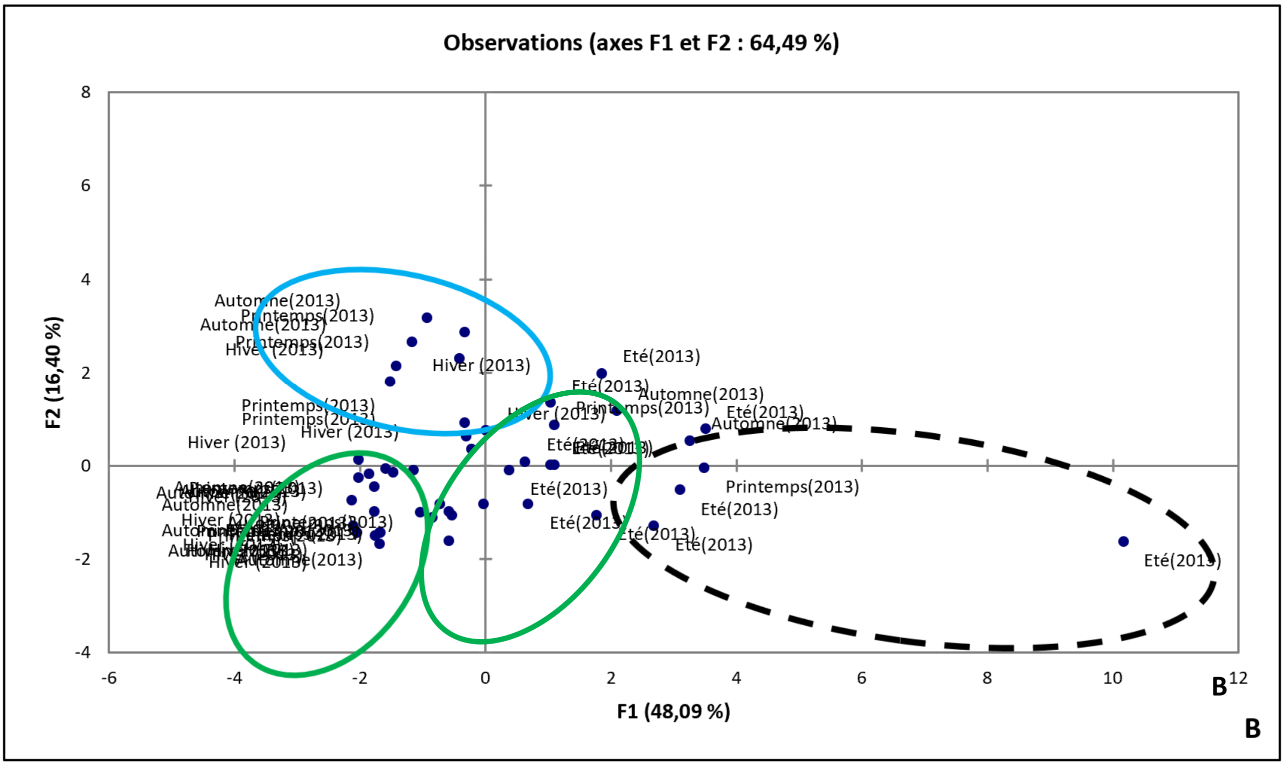


Fig. 12. Spatial (A) and temporal (B) distributions of the physicochemical and bacteriological parameters according to the F1xF2 plan of the ACP

Thematic analysis of maps for physicochemical and bacteriological parameters

The use of the Water Quality Assessment System (WQAS) has allowed us to re-classify properly the water quality class of our wetlands. The key figures in Table 03 are an extract from the water evaluation grid 2-2003 version. Following the quality index for each alteration parameter is the result of the correspondence between the values of concentration of this latter and an index ranging between 0 and 100 (Tab.04).

Table 3. Classes and quality indices

Parametre class	bleu	green	yellow	orange	red
T(°c)	‹20	20-22	22-25	25-30	›30
pH	6,5	8,5	9	9,5	›9,5
Electrical conductivity (µS/cm)	‹400	400-750	750-1500	1500-3000	›3000
Dissolved oxygen(mg/l)	8	6	4	3	‹3 - ›13
NO3(mg/l)	2	10	25	50	›50
NO2(mg/l)	0,03	0,3	0,5	1	›2
PO_4^{-3} (mg/l)	0,1	0,5	1	2	›2
TC (u/100ml)	50	500	5000	10000	›10000
FC(u/100ml)	20	200	2000	20000	›20000
FS(u/100ml)	20	200	1000	10000	›10000

Bleu	Very good
Vert	Good
Jaune	Fair
Orange	bad
Rouge	Verybad

CARTOGRAPHY

To properly determine the concentration distribution of the different elements on the map, we have used the classes and indices of the WQAS grid for each parameter presented by a point size changing according to the key-figures interval expressed for the quality of the water for each parameter.

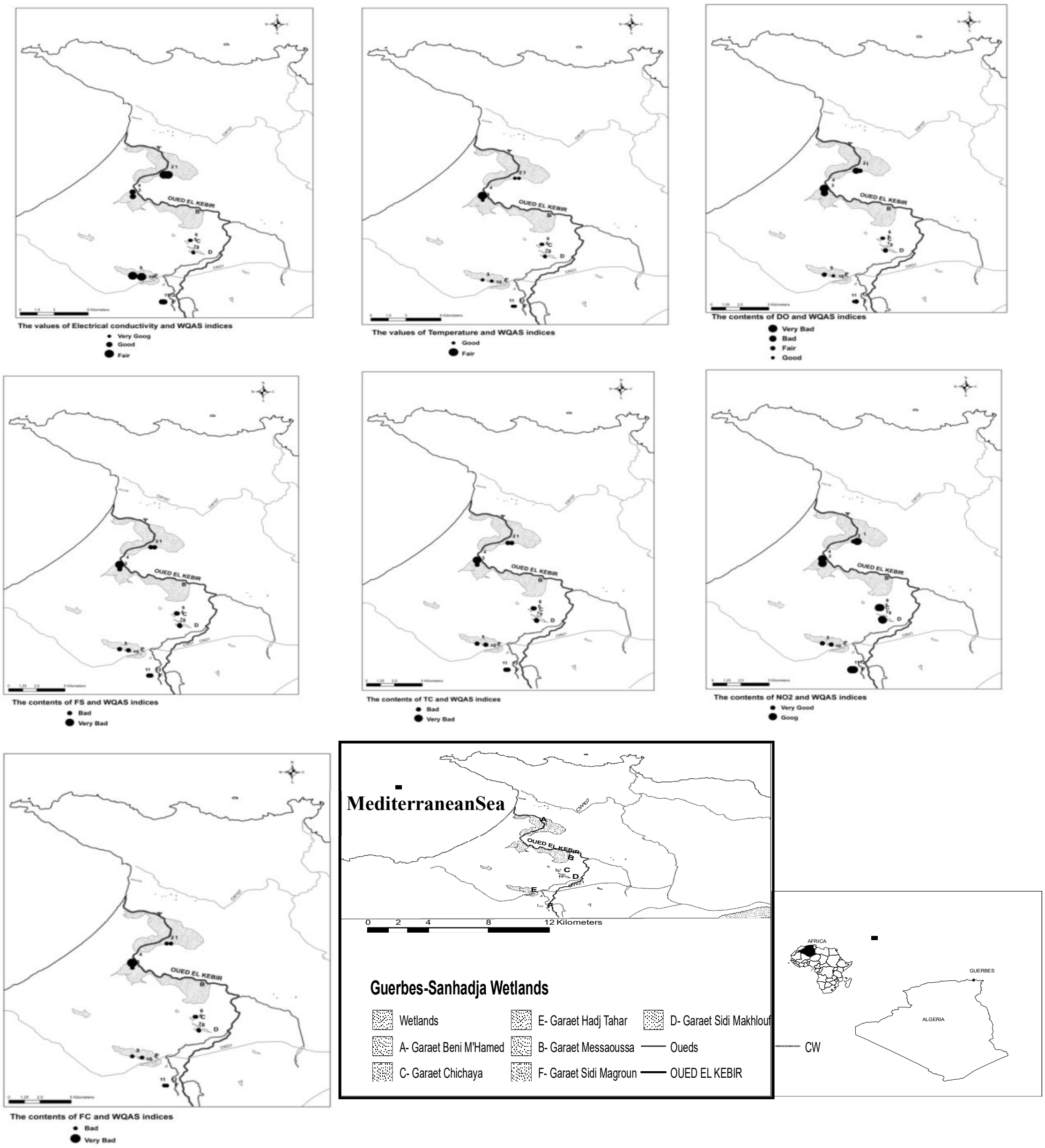


Fig. 13. Concentration distribution of the different elements on the cart using ARC Gis

4 CONCLUSION

This work was devoted to the study of the bacteriological and physicochemical quality of main wetlands water of Guerbes-Sanhadja complex, based on the determination of certain pollution indicators. All of the water samples studied are of fair to good quality with a minimal contamination, at exception of Garaet Lemsaouessa and Garaet Chichaya. These are marked by the particular presence of fecal contamination indicators.

The good quality of water in these wetlands, far from all sources of dangerous pollution except for some cases of urban discharges or manure (agricultural zone), makes these water bodies a favorable place attracting a very diversified aquatic bird life especially during winter. It represents also a reservoir of fresh water for groundwater recharge and even for use in agriculture if conditions are favorable. That is why we stress the importance of preserving and maintaining these wetlands as a natural resource, by caring for and preserving them in order to ensure a more balanced ecosystem.

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