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Evaluation the Impact of Intensive Agriculture on Physic- Chemical Properties of Soil and Groundwater in the Rural Commune Sfafaa (*Sidi Slimane, Gharb, Morocco*)

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Abstract

The objective of this study was to assess the impact of intensive agriculture on the physic-chemical quality of water and soil. We have conducted a qualitative study of waters and soils of the irrigated perimeter of Sfafaa located in the province of Sidi Slimane, Gharb (Morocco). The approach includes campaigns of measurements in situ (pH and depth of the water table) as well as the analysis in the laboratory to determine the physic-chemical parameters of soil. Seventeen water points and soil were prospected over a period, starting from March to June during two years (2013 and 2014).Data were statistically analyzed using the method of analysis of variance (ANOVA).The results showed that the depth of water table varies between 9 and 12 m. In addition, that 70.6% of the studied wells were highly to extremely saline and then inadequate for irrigation. As regards the physic-chemical characteristics of the soil, the results show that the samples are poor to moderately poor in organic matter but contain high levels of potassium. Concerning phosphorus, the levels are low to high. On the other hand, we found a significant difference between 6 zones in terms of pH, pH(KCl), the K_2O and electrical conductivity. The use of waters with poor quality for irrigation leads the problem of degradation of soils by accumulation of salts. This accumulation is more-or-less important as a function of the quality of water, the nature of soil, the climate and the mode of irrigation.

1. Introduction

In Morocco, the degradation of soils and waters is a problem that accumulates and amplifies [1]. This pollution decreases the potential of the water resources of the good quality and generates health risk for rural population [2-3]. Previous studies have targeted the quality of waters and soils in the irrigated perimeters in Morocco [2,4-6]. All over the world, studies have stressed the problem of degradation of soil and groundwater quality [7], which can limit the long-term agricultural production and cause irreversible deteriorations.
These deteriorations are due to the mismanagement of irrigation water and agro-chemical inputs. Indeed, salinization and sodification of agricultural lands, resulting from irrigation with marginal and poor-quality water (mainly groundwater), are increasing rapidly [8]. Hence; around 30% of world irrigated surface is saline. The Mediterranean region registers approximately 16 million hectares [2].
The agricultural activities in the Gharb (Morocco) are considered to be among the potential factors that may contribute to the degradation of the quality of water and soil. More over the groundwater resources of the Gharb are contaminate by the organochlorine pesticides (0.03-0.3µg/L) [9].
In this context, the present work is interested in the commune of Sfafaa, characterized by intensive agricultural activities; to check to what extent these activities have affected the quality of soil and water in this region.

2. Materials and methods

2.1. Presentation of the study zone

The study zone belongs to the Province of Sidi Slimane, located around the geographic coordinates 34° 15′0" and 6° 9′36", it is limited to the north by the Province of Sidi Kacem , in the south-east by the rural commune of

Boumaiz (Province of Sidi Slimane), and to the west by the rural commune of Kecybia (Province of Sidi Slimane), the rural commune of Sfafaa extends over approximately 197km^2.
The Fertile land, a temperate and humid climate and the abundant water resources of the commune of Sfafaa, make of it an agricultural zone of first importance. This commune is a natural collector of surface waters. Its flat morphology (the majority of the plain with a coast lower to 12 m) disfavors the evacuation from flood waters of the river up to the sea.

2.2. Methodology
The methodology consists of the realization of soil and water sampling during the period March to June (2013 and 2014). The levy is based on a mesh well developed using a topographic map of the study area. These samples are divided into 6 different zones: A, B, C, D, E and F (Figure 1).

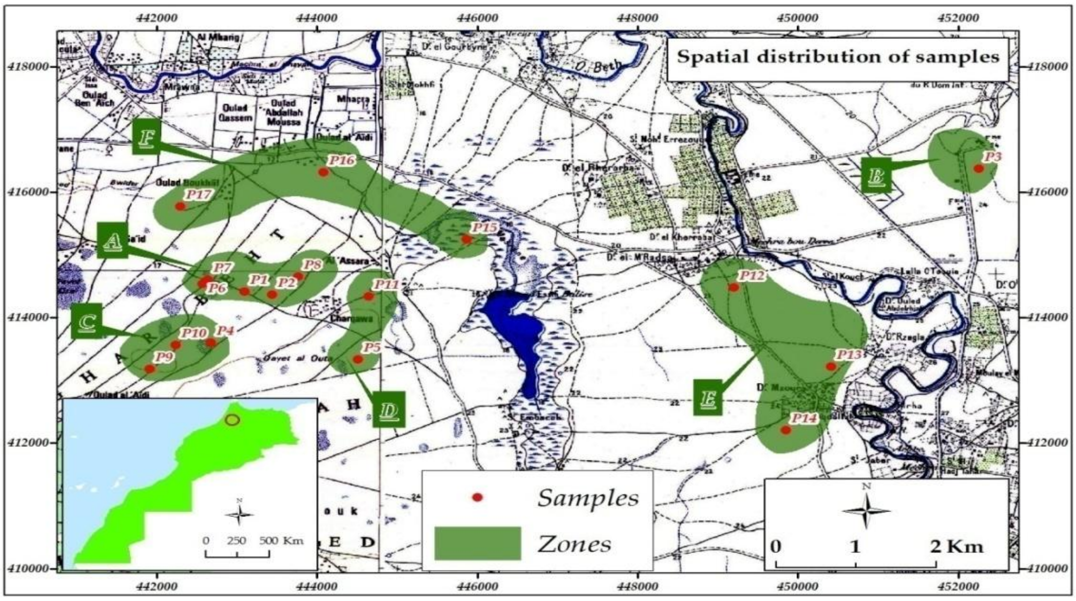

Figure 1: Presentation of the study zone and prospected soils and wells.

2.2.1. Soil
The study has focused on 17 sites. The samples were collected from the 0-20cm horizon with the help of an auger. They were dried in the open air and then crushed and sieved. These samples were analyzed for the following physic-chemical parameters: pH(water), pH(KCl), electrical conductivity (EC), organic matter (OM), available phosphorus (P_2O_5) and exchangeable potassium (K_2O).

- pH is determined by the potentiometric method using the Mettler Toledo Seven Easy-728 Metrohm pH meter [10].
- Electrical conductivity (EC) is measured by the method of the saturated paste using a conductivity meter of Orion brand, model 162. The result is expressed in dS/m [11].
- Organic matter (OM) has been evaluated according to the method of Walkely and Black, which consists of an oxidation of the organic fraction of carbon by potassium dichromate ($K_2Cr_2O_7$ to 1N) in acid medium and a titration in return by of Mohr'salt ($(NH_4)_2$ Fe SO_4, ,$6H_2O$ at 0,5N). The result is expressed percentage of carbon (%C)[12].
- Available phosphorus (P_2O_5) is determined by the method of Olsen using a UV visible spectrophotomete -JENWAY6405 Model at a wavelength of 825 nm. The result is expressed in ppm [13].
- Exchangeable potassium and sodium: the extraction is done by the ammonium acetate CH_3COONH_4 1N at pH 7. The levels of K_2O and Na^+ are determined by means of a flame photometer model CL 378. The results are expressed in ppm [10].

2.2.2. Water
For groundwater, 17 water points are sampled at the level of the existing wells near the points of the collected soil samples quality parameters have been measured in situ, including the groundwater depth and pH. The water

samples were placed in plastic bottles and kept in a cooler (2 to 4°C), Maximum 72 hours, and then forwarded to the laboratory for the physic-chemical analyses.

2.2.3. Statistical analysis

All the soil and water parameters, we processed using the one factor analysis of variance (ANOVA) to check whether there is a difference between the 6 zones.

ANOVA will verify if the means of the different quality parameters for the 6 zones are statistically different [14]. The significance of the difference between the zones is expressed by the F ratio of Fisher-Snedecor as well as the corresponding probability value (p-value). The difference is considered statistically significant when this p-value is less than 0.05. When ANOVA results are statistically significant, a multiple comparison of means using the Duncan test has been done [15].

3. Results and discussion

The results of measurement of various physic-chemical parameters of the soils are presented in table 1.

In this table, values are expressed as means ± standard deviations.

Table 1: Means ± standard deviations of the physic-chemical parameters for the 6 zones and the ANOVA significance test.

Parameters	Zones						Signification	
	A	B	C	D	E	F	F value	P value
pH(water)	5.2 ± 2.4	7.9±0.3	6.6 ±0.4	6.7 ±0.5	8.0±0.2	7.7±0.4	4.00	0.006
pH(KCl)	4.7±2.2	7.2±0.4	5.9±0.4	5.9±0.2	7.5±0.1	7.1±0.4	4.32	0.004
OM (%)	1.5±0.8	2.0±0.5	1.7±0.6	1.9±0.9	2.4±0.6	1.6±1.2	0.91	0.487
P_2O_5 (ppm)	93.2±70.8	40.6±18.0	85.0±39.7	44.5±36.8	67.9±89.0	20.7±12.8	1.62	0.181
K_2O (ppm)	112.6±70.9	228.2±108.5	133.6±58.0	208.0±141.7	162.5±12.0	287.0±64.9	4.60	0.003
E.C (dS/m)	1.6± 0.7	2.3±0.7	1.7±0.4	0.6±0.1	2.6±0.9	3.4±0.6	11.35	0.000

We will detail below the results of each parameter as well as the comparison between the different zones.

3.1. Quality of soil

3.1.1. pH (water)

The pH is an important parameter of the dynamics of the soil. It is a key in agronomy because the levels of acidity or basicity of the soil plays a very important role in the assimilation by the plant ,of nutrients, and it has an influence on three major components of the fertility of a soil: the bioavailability of nutrients, the biological activity and the structural stability, pH variation depends on the seasonal variations and the buffering capacity of soil (the number of ions in the reserve on the clayey-humic complex) ,the water status of the soil, its temperature and the presence or not of a crop in period of active growth phase [16,17].

The study of the distribution of the pH as a function of the zones revealed a significant difference ($F=4.0$; $p=0.006$) which implies that this parameter differs from one zone to the other.

In fact, the results of the Figure 2 show that the soil of the zone F is weakly basic with a mean of 7.7±0.4 while that of the zones B and E is moderately basic with 7.9±0.3 and 8.0±0.2, respectively [18].

Subsequently we have done a multiple comparison of mean using the Duncan test which revealed the existence of two different groups of zones:

- The first group contains the zones A, C, and D, with a mean of 6.2
- The second group corresponds to zones B, C, D, E, and F with a mean of 7.4

3.1.2. pH (KCl)

It is to measure the pH after the addition of potassium chloride (KCl); the latter is going to hunt the protons fixed on the clayey-humic complex and allows you to reflect also the potential acidity or exchange of the soil, fixed on the exchange complex.

The study of the pH(KCl) as function of the 6 zones showed a significant difference ($F=4.32$; $p<0.05$) which implies that this parameter differs from one zone to the other.

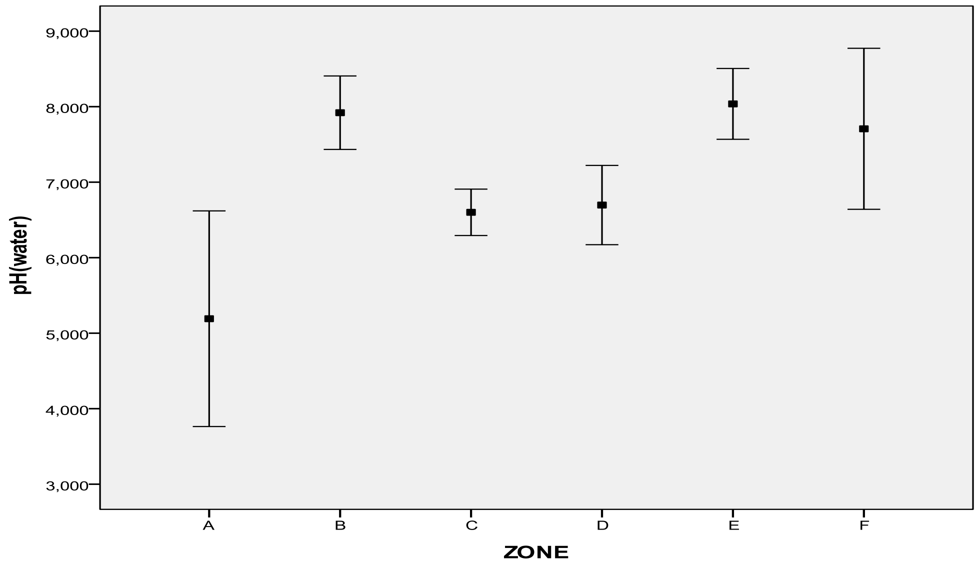

Figure 2: Mean values of pH as function of the 6 zones.

In effect, the results of Figure 3 show that the soil of the zone E is weakly basic with a mean of 7.5±0.1 while the zone A is acid with a mean of 4.7±2.2.
The Duncan test for a multiple comparison of means showed the existence of two different groups of zones: the first group (zones A, C, and D) with a mean of 5.5 and the second group (zones B, C, D, E, and F) with a mean of 6.7.

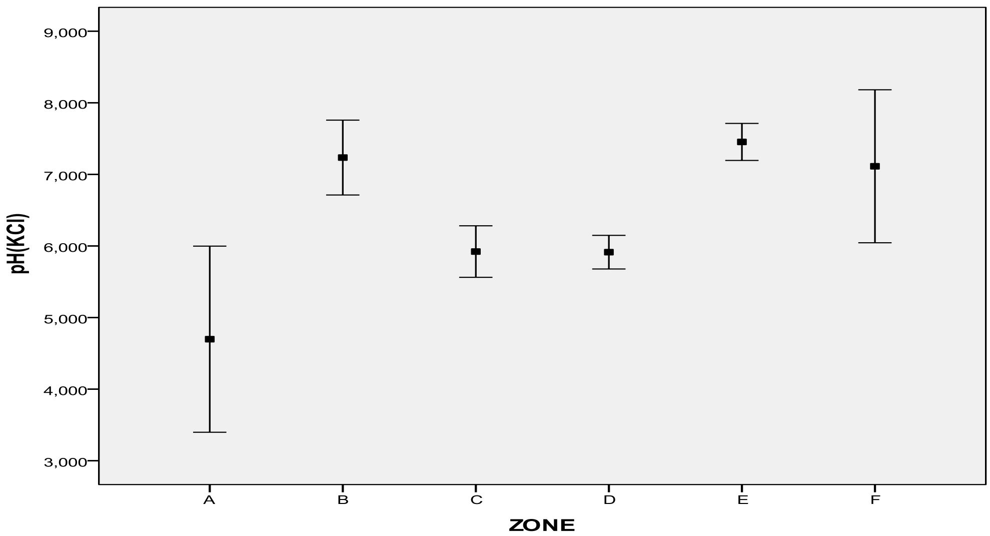

Figure 3: Mean values of pH (KCl) as function of the 6 zones.

3.1.3. Organic Matter

The organic matter of the soil is an important indicator of the quality of the soil [19-22] through its contribution in the stability of the soil, the increase in water-holding capacity of the soil, the fixing of mineral elements, and the substrate for microorganisms in the soil. The organic matter content of the soil is influenced globally by climatic factors, vegetation, the texture of the soil, the topographical conditions, influencing the microclimate and drainage and cropping practices [18].
The results show that the studied soils are poor to moderately poor in terms of organic matter, content 70.6% being moderately poor [18]. This could be explained by the influence of climate and farming practices. In fact, the farmers of the region do not leave much crop residues on the soil as well as they do not bring frequently of organic amendments such as manure, compost,….,which negatively impacts the quality of soils.
The mean organic matter content of the zone E reaches 2.4% (Figure 4).
As regards the distribution of organic matter according to the zones, the results of the ANOVA show (Figure 4) that the levels do not differ significantly between zones (F=0.91 ;p >0.05).

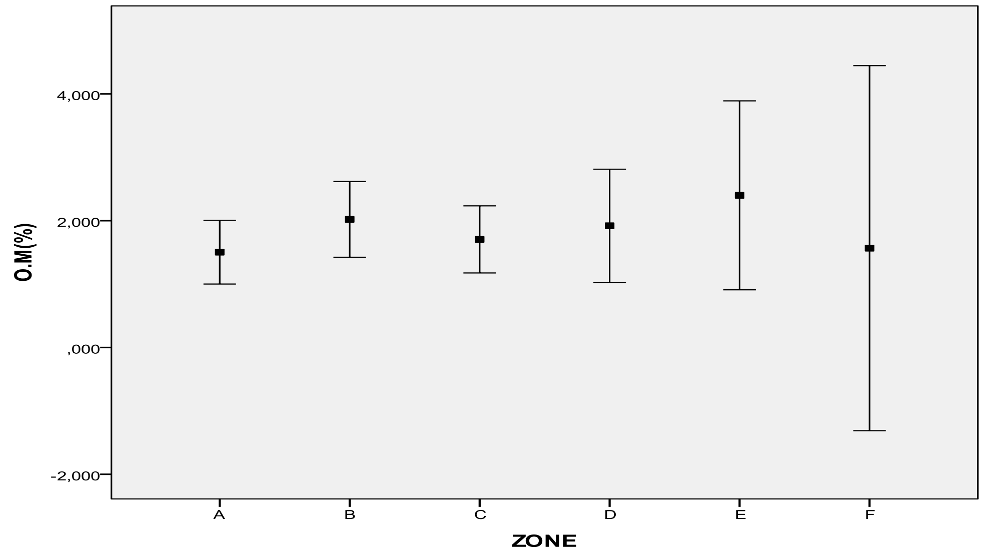

Figure 4: Mean values of organic matter (O.M) as function of the 6 zones.

3.1.4. Phosphorus

Phosphorus is one of the major elements essential to the growth and development of plants.

It plays in particular an essential role in the establishment of the root system, photosynthesis and the reproduction of the plant. Its content depends on the physic-chemical properties of the soil [23].

In general, the results of studied soils show that almost 50 % of the soils are characterized by a high content of available phosphorus. Therefore, the highest content of phosphorus (93.2 ppm) is obtained in the case of the zone A. whereas the lowest value (20.7ppm) corresponds to the F Zone (Figure 5).

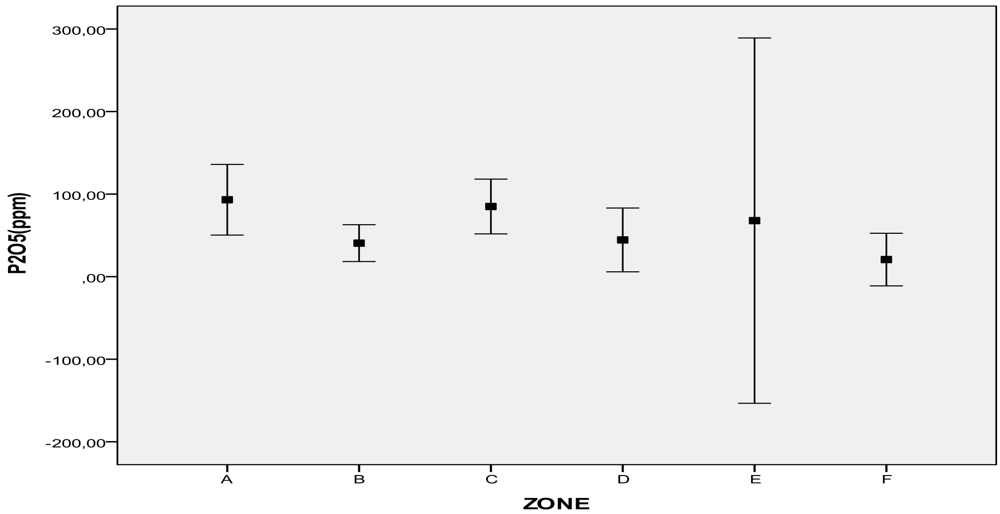

Figure 5: Mean values of available phosphorus P_2O_5 as function of the 6 zones.

3.1.5. Potassium

Potassium is absorbed by the plant in its ionic form K^+. It is essential for the translocation of sugars and for the training of the starch. It intervenes in osmotic regulation and ion, as well as in the process of opening and closing of the stomata. Potassium is necessary for several enzymatic functions and for the metabolism of proteins and carbohydrates. Its content depends on the physic-chemical properties of the soil [11].

The mean K_2O value is 288.2ppm, which indicates that these soils are rich in potassium (Figure 6). These levels are explained by, on the one hand, the nature of the soils of the Gharb characterized by high rates of clay and, on the other hand, a poor reasoning of the potassium fertilization. The excess of potassium may transform into salt and pollute as well groundwater by percolation and infiltration. In addition these high levels of potassium can also cause deficiencies of magnesium for crops [24]. The statistical analysis shows a significant difference between the 6 zones as regards the potassium (F=4.60; p=0.003). Indeed, the zones B, D, and F contain the most rich soils in potassium.

The comparison of the mean by Duncan test has revealed the existence of two groups.
The first group (zone A, C, D, and E) with a mean of 154.2ppm and second group (zone B, D, and F) with a mean of 261ppm.

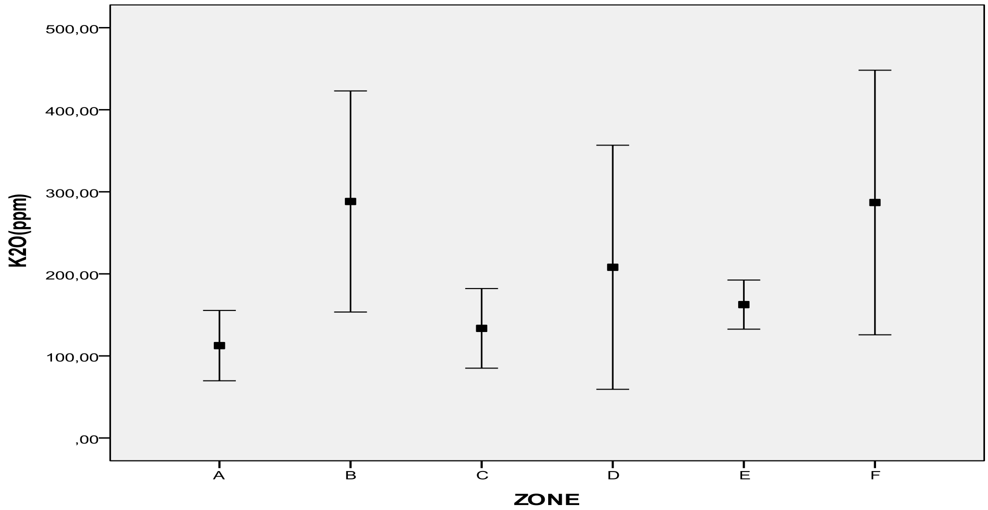

Figure 6: Mean Values of exchangeable potassium K_2O as function of the 6 zones.

3.1.6. Electrical conductivity (EC)
The zones have significantly different EC levels (F=11.35; p=0.000). The zone F is, by far, the most concerned by the salinity (Figure 7) with a mean of 3.4±0.8 dS/m, followed by zones E and B with 2.6±0.9 dS/m and 2.3±0.7 dS/m respectively. These levels of salinity relatively average that face the farmers in the region can be overcome by managing the irrigation and reasoning the fertilization in order to avoid land degradation. The multiples comparison of means using the Duncan test showed the existence of four different groups of zones:
-The first group contains the zone D of with a mean of 3.6 dS/m.
-The second group contains the zones A, B, and C with a mean of 1.9 dS/m.
-The third group contains zones B and E with a mean of 2.45dS/m.
-The fourth group corresponding to the zone F with a mean of 3.4 dS/m.

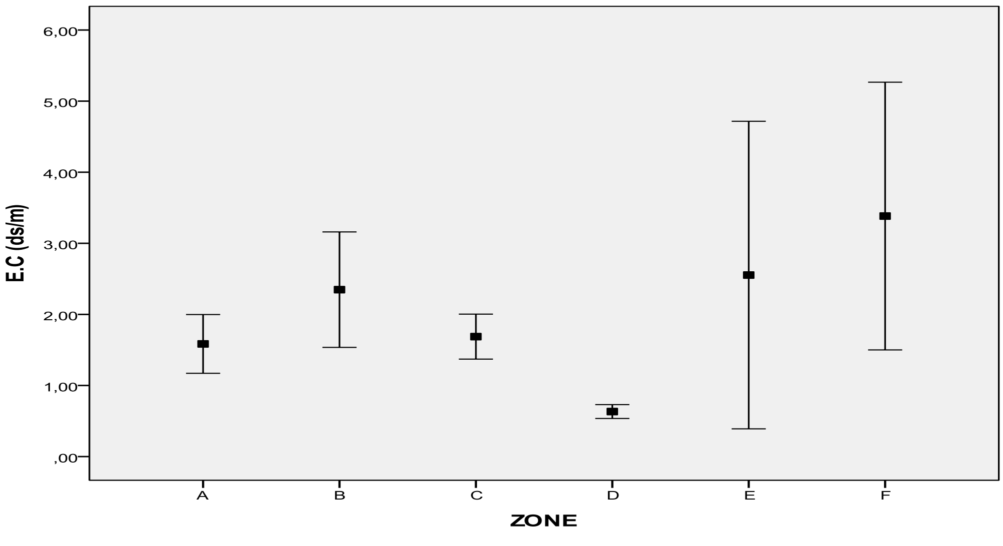

Figure 7: Mean values of electrical conductivity (E.C) as function of the 6 zone.

3.2. Quality of Water
Table 2 presents the classification of waters according to the U.S.S.L standards for the classification of irrigation water. It is clear from these results that 70.6% of the wells belong to the C3, C4 and C5 classes. These waters are considered to be extremely saline and therefore, unsuitable for irrigation because they have a higher potential for soil salinization and may cause significant yield reduction, especially for sensitive crops.

Table 2: Distribution of irrigation water salinity of the Sfafaa's region, following the USSL standards [11].

Salinity class	Symbol	EC (mS/cm)	Number of wells	% of wells
Non saline	C1	<0.25	**0**	0.0
Averagely saline	C2	0.25-0.75	5	29.4
Highly saline	C3	0.75-2.25	7	41.2
Very highly saline	C4	2.25-5	4	23.5
Extremely saline	C5	>5	1	5.9

Conclusions

The study of the physic-chemical quality of water and soil of the region of Sfafaa has allowed us to assess the current state of the quality of soil and water in this region particularly known for intensive agricultural activities:

- Soils are, in general, moderately poor in organic matter and the majority of them present high levels of phosphorus and potassium due mainly to the nature of the soils of the Gharb region and to the lack of control of mineral fertilization.

- Relatively average levels of soil salinity have been observed thus compromising the sustainable use of the agricultural land in the region. This phenomenon is accentuated by the irrigation waters since more than 70.6% of the waters have an important power of salinization, especially in the upstream and downstream parts of the region.
- The level of the water table relatively less deep (less than 12 m) further exacerbates the phenomenon of salinization of soils by the capillary rise of waters generally saline.

- Eventually, in order to maintain a sustainable productivity of the Sfafaa's lands as well as preserving water and soil resources from degradation, we recommend to the farmers of this region to adopt best management practices especially: better control of the irrigation through water saving techniques, better reasoning of mineral fertilization as well as the frequent addition of organic amendments to the soils.

Acknowledgments--The present work has the objective to contribute to the enhancement of the sustainable development of agriculture in the region of Rabat-Salé-Kénitra. We want to thank all the people who have helped me in the field and in the laboratory throughout this work.

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