Ecological and Agricultural monitoring of Sebou river waters at Kariat Bamohamed (Taounate-Morocco)

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Abstract**—** *Kariat Bamohamed is an agricultural region located to the west of the city of Taounate and north of the city of Fez. The surface waters in the region are mainly composed by the Sebou river and many natural springs.*

The study concerns the analysis of hydrochemical parameters (T°, pH, CE, MES, O_2, BOD_5, COD, Cl-, PO_4^3, NH_4+ and NO_3-) along the middle Sebou river region of Kariat Bamohamed in order to establish a diagnosis of the state of pollution of the surface waters of this part of the river. Water sampling was carried out at four study stations during flood period and during low water period.

In the light of the results obtained on the surface waters of the Sebou river, it is concluded to a degradation of water quality in both the winter and summer periods. In particular, an increase in the values of ammonium, COD and BOD_5 in addition to an acidic pH due to margine discharges and leaching of fertilizers and other discharges of wastewaters from the cities of Fez and Kariat Bamohamed.

Keywords— Sebou River, Waters, Hydrochemistry, Irrigation, Kariat Bamohamed, Morocco.

I. INTRODUCTION

In Morocco, superficial flows are dependent on rainfall and exhibit high spatial variability [1-2]. In general, the water resources available to Morocco are limited and subject to extreme cyclical variations [3]. Similarly, the qualitative situation of the waters is far from satisfactory [4]. Indeed, population growth accompanied by rapid urbanization that causes many disturbances to natural environments [5]. Industrialization, the irrational use of fertilizers and pesticides and the lack of awareness of the population towards the protection of the environment, lead as much to an imbalance of the ecosystem and generate polluting elements that can affect the physico-chemical quality biological and aquatic receiving environments [6], but also alter the uses of water; water collection, swimming ... etc [7].

The sub-basin of Sebou river drains the Kariat Bamohamed region and is particularly affected by the problem of continuous development of the agricultural sector [8]. Indeed, discharges of wastewaters, pesticides and fertilizers drained by rainwater and irrigation, in addition to domestic discharges generated by the small town of Kariat Bamohamed and the city of Fez are dumped directly into the Sebou river [9].

The present research on the Bamohamed region is aimed at the prospection of the hydrochemistry of the waters of the Sebou river. The study will be based on a monitoring of the indicators of the physicochemical pollution of the water and the determination of the seasonal fluctuations of these parameters between the period of low water and the period of flood.

II. MATERIAL AND METHOD

2.1 Study area

Kariat Bamohamed is a region of Taounate province of high agricultural intensity. It is located at 34° 22 '08 " North and 5° 12' 35" West. 58 km northwest of the city of Fes and 90 km west of the city of Taounate (Fig. 1). Its population is estimated at about 20000 inhabitants. The area includes the town of Kariat Bamohamed surrounded by several rural communes (Bni Snous, Sidi El Abed, Sidi Daoud, Sebt Loudaya, Mkansa).

2.2 Study method

2.2.1 Sampling

Four stations S1 to S4, distributed along the Sebou wadi (Fig. 1), have been retained in such a way that they are accessible and reflect the real characteristics of the surface waters of Sebou river at the level of the Kariat Bamohamed study.

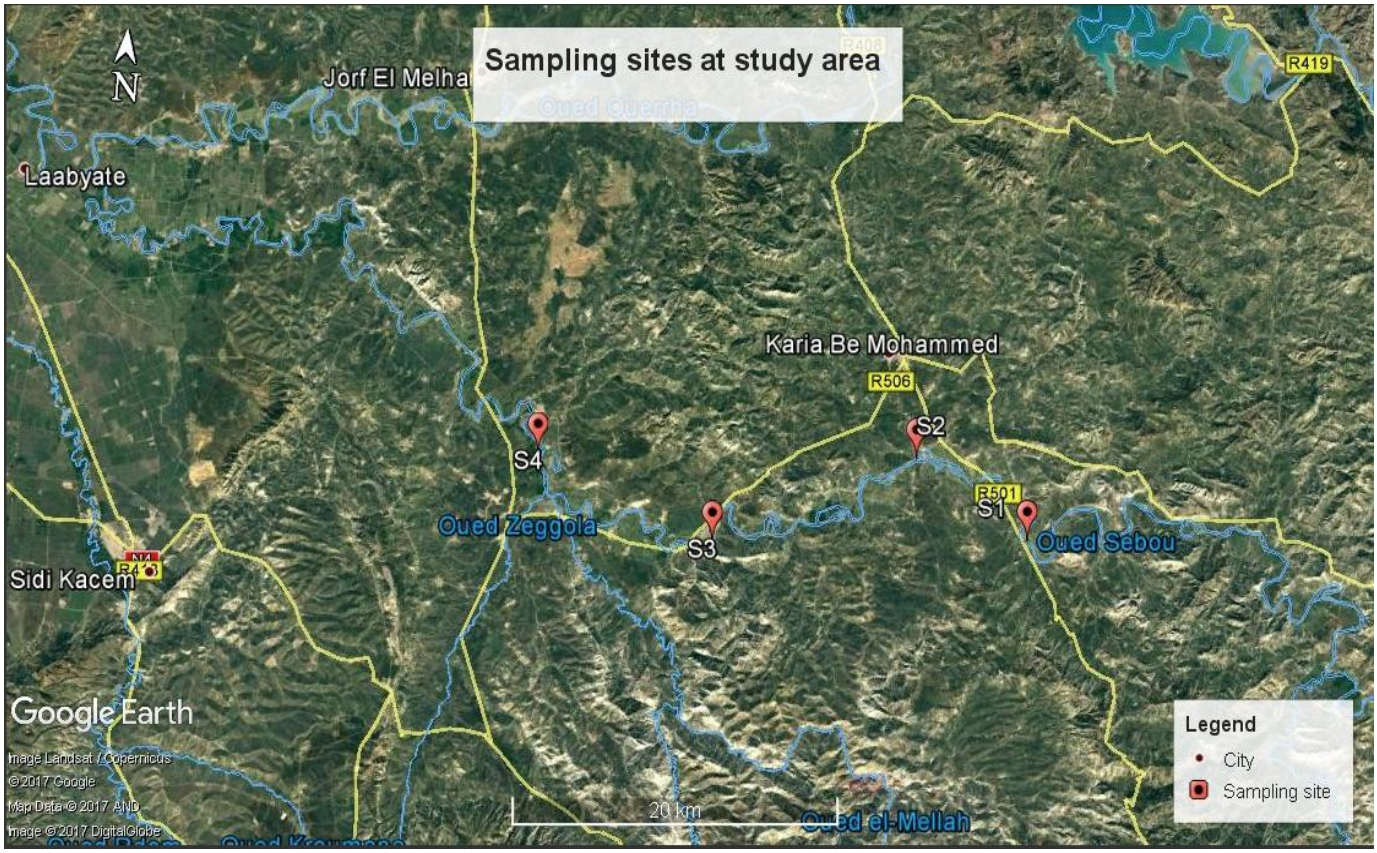

FIGURE 1: LOCATION OF SAMPLING STATIONS (S1, S2, S3 AND S4) AT THE SEBOU RIVER OF KARIAT BAMOHAMED

2.2.2 Sampling and analysis

Along the Sebou river and throughout the study area (**Fig.2**), water samples were taken during wet periods (December, January and February) and in dry periods (June, July and August). The wet period has an intense rain and a violent flood.

At each sampling, the samples were kept in plastic bottles, previously rinsed with water from the station. The bottles were then transported to the laboratory at 4 ° C.

The temperature is measured "in-situ" using a mercury thermometer graduated 1/10 from 0 to 50 ° C. The hydrogen potential (pH), the EC electrical conductivity, the dissolved oxygen (O2) are determined using a CONSORT-Model 835 multi-parameter analyzer, an oxymeter and a pH meter.

The suspended solids MES are determined by filtration of a volume of water on a 0.45 µm cellulose filter according to Rodier [10].

The BOD5 is determined by the respiratory method using a BOD-meter brand WTW, model 1020T according to the technique described by DIN [11].

The COD is determined by acid oxidation by the excess of potassium dichromate at the temperature of 148 ° C of the oxidizable materials under the conditions of the test in the presence of silver sulphate as catalyst and mercury sulphate according to DIN [12].

The chlorides are determined by a volumetric acid determination (HNO3) by a solution of mercuric nitrate in the presence of a pH indicator.

Nitrates, ammonium and orthophosphates are analyzed by colorimetric methods using a Visible Type 722 S Beijing UV spectrophotometer.

FIGURE 2: SAMPLING WATERS AT KARIAT BAMOHAMED SEBOU RIVER AREA

III. RESULTS AND DISCUSSION

3.1 Water temperature

In the study area, recorded temperatures (**Tab.1**) oscillate between 9 °C (station S1) and 12 ° C (stations S3 and S4) during wet periods, and between 25 ° C (S4) and 27.68 ° C (S4) in dry period. These variations follow the temperature of the climate of the region. With measured water temperatures of 9 to 27.6 ° C, the Sebou river belong to the middle class to excellent according to Moroccan standards [6, 13].

3.2 pH

The pH is a measure of the acidity of the water, that is to say the concentration of hydrogen ions (H +). The pH scale extends in practice from 0 (very acidic) to 14 (very alkaline); the median value 7 corresponds to a neutral solution at 25 ° C.

The observed values (**Tab.1**) reveal that the pH is acidic in the rainy period, and neutral to slightly alkaline in the dry period. The pH varies between 5.8 (S1) and 6.8 (S3) in winter and between 7.1 (S2) and 7.8 (S4) in summer. This is probably due to the discharge of vegetable water in December and January from several oil mills between Fez and Kariat Bamohamed.

3.3 Suspended materials

For both flood and low water seasons, recorded values range from 128 mg / L to 3200 mg / L. The spatio-temporal evolution of suspended solids content (MES) (**Tab.1**) in Sebou river shows two distinct periods:

- A winter period, where heavy loads recorded in all stations between 3200 mg / L (S1) in December 2014 and 2450 mg / L (S3) in February 2015. These high levels may be the result of a sudden hydrological event (flood), whose load in alluviants can be attributed to an intense erosion of the watershed, following stormy rains, accentuated by discharges of water-gardens;

- A summer period, where concentrations drop in all stations from 128 mg / L (S1) in August 2015 to 165 mg/L (S3) in June 2015.

The comparison of the contents of suspended solids in the Sebou medium with the Moroccan standard set at 1000 mg / L places these waters in the medium to very poor grid [13].

3.4 Electrical conductivity

The measurement of the conductivity is a good appreciation of the degree of mineralization of water where each ion acts by its concentration and its specific conductivity.

The average recorded values of conductivity (**Tab.1)** show that they fluctuate between 240 µS / cm and 320 µS / cm during flood water periods. These low levels are due to dillution by the rains. In the dry period, the intensities of the electrical conductivity increase and vary between 2730 µS / cm and 3340 µS / cm exceeding the Moroccan standard for surface water (2700 µS / cm) [13]. This indicates excessive mineralization attributed mainly to wastewater from the city of Fez.

TABLE 1
STATISTICAL DATAS ON HYDROCHEMICAL ANALYSIS OF SEBOU RIVER AT KARIAT BAMOHAMED (MOROCCO)

	Stations	déc-14	janv-15	févr-15	juin-15	juil-15	Aout-2015
T°C	S1	9.14	9.12	11	25	26.24	27.44
	S2	10	9.67	10.68	25.34	26.42	28
	S3	10.42	9	10.14	26	27.12	27.68
	S4	11.12	10	12	26.22	27.14	27
pH	S1	5.8	6.2	6.7	7.1	7.6	7.4
	S2	6.1	6.3	6.8	7.1	7.7	7.4
	S3	5.9	6.3	6.6	7.3	7.8	7.6
	S4	6.2	6.4	6.7	7.2	7.5	7.7
O_2 mg/L	S1	2.12	2.86	4.22	3.22	3.66	2.18
	S2	2.08	3.1	4.48	3.44	2.88	2.34
	S3	3.24	2.64	4.84	2.98	3.22	2.48
	S4	2.84	2.42	4.78	4.18	2.22	2.1
CE µS/cm	S1	320	280	240	2830	3120	3320
	S2	290	284	250	2780	2950	3340
	S3	310	300	264	2980	3240	3325
	S4	295	265	268	2870	3180	3125
Cl- mg/L	S1	840	770	760	884	986	1420
	S2	1220	842	784	820	1120	1530
	S3	1620	920	820	790	1220	1600
	S4	980	910	910	834	1240	1130
MES mg/L	S1	3200	2860	2460	156	148	128
	S2	3140	2670	2480	162	152	130
	S3	2760	2630	2450	165	146	132
	S4	3050	2480	2520	157	140	129
DBO5	S1	8	6	5	14	18	22
	S2	10	8	5.8	16.2	19	21.8
	S3	9	9	6.2	16.4	20.4	20.6
	S4	8	10	6.4	16.8	20	21.9
DCO	S1	12	10	8	22	40	36
	S2	14	17	9.5	34	38	32
	S3	16	16	9	36	28	30
	S4	12	15	11	24	32	29
PO_4^{3-} mg/L	S1	0.58	0.53	0.56	0.82	0.86	0.92
	S2	0.6	0.72	0.53	0.84	0.88	0.89
	S3	0.62	0.76	0.58	0.86	0.84	0.91
	S4	0.7	0.68	0.61	0.9	0.85	0.9
NH_4+ mg/L	S1	2.66	2.7	2.44	2.54	2.77	2.76
	S2	2.68	2.76	2.48	2.58	2.78	2.8
	S3	2.7	2.78	2.56	2.62	2.76	2.78
	S4	2.78	2.82	2.52	2.57	2.79	2.81
NO_3- mg/L	S1	14.24	15	14	2.12	1.45	1.8
	S2	16.62	16.2	16.22	2.14	1.66	1.66
	S3	19.45	20.18	17.1	2.21	1.88	1.76
	S4	18.34	20.42	17.8	2.28	1.84	2

3.5 Chlorides

Chloride ion concentrations in the waters of Sebou river at Kariat Bamohamed (**Tab.1**) ranged from 760 mg / L (S1) to 1620 mg / L (S3) during flood periods and between 720 mg / L (S1) and 1600 mg / L (S3) in the low water period. This evolution indicates the influence of an anthropic contribution which can be of urban or industrial origin. For both periods of study, chlorides record levels that exceed the Moroccan standards set at 750 mg / L [13]. This makes it possible to classify these waters in the bad grid of the surface waters.

3.6 Dissolved oxygen

Oxygen is an excellent indicator of water quality. This is one of the most sensitive parameters to pollution. Seasonal evolution of dissolved oxygen shows low concentrations; in fact, the recorded levels (**Tab.1**) vary between 2.08 mg / L and 4.84 mg / L and between 2.1 mg / L and 4.18 mg / L respectively during the flood period and during the dry period.

The low levels recorded during the rainy season are mainly due to the rejections of the vegetable waters and also to the self-cleaning capacity which is inhibited. However, during the summer season, the warming of the water and the low flow of the river cause a decrease in the dissolution of dissolved oxygen, aggravated by an increase in oxygen consumption by living organisms in the water. River and a drop in wind speed in addition to the organic load of urban discharges from the city of Fes and the town of Kariat Bamohamed.

Our results show that the waters of the Sebou river at the level of the study area are of bad quality to very bad quality [13].

3.7 Biochemical oxygen demand

BOD_5 or biochemical oxygen demand is the amount of dissolved oxygen consumed by microorganisms in the dark and at 20 °C for 5 days to degrade organic matter. It allows the evaluation of the biodegradable organic matter overload.

BOD_5 values range from 5 mg / L to 10 mg / L in winter and from 14 mg / L to 22 mg / L in dry periods (**Tab.1**). The increase in BOD_5 levels in the dry period can be explained by the introduction of conditions of degradation of organic matter by microorganisms whose activity intensifies with the decrease of the flow rate and with the warming of water. This activity, which consumes oxygen, is at the origin of self-purification of water [13]. On the contrary, during wet periods, rainwater contributes to the dilution of the organic load emanating from urban wastewater.

3.8 Chemical oxygen demand

The chemical oxygen demand (COD) represents the amount of oxygen consumed by the chemical oxidation of the materials contained in the water. It represents most of the organic compounds but also oxidizable mineral salts (sulfides, chlorides, etc.).

The levels of COD recorded in the water studied range from 8 mg / L to 17 mg / L during the flood period and from 22 mg / L to 40 mg / L during the dry period (**Tab.1**). The grid of Moroccan standards makes it possible to classify these waters as of average quality [13].

3.9 Orthophosphate

Orthophosphates follow relatively marked spatial variation with a tendency to increase in the dry period. The recorded values (**Tab.1**) range from 0.53 mg / L to 0.76 mg / L in the flood period and from 0.82 mg / L to 0.92 mg / L. This availability of orthophosphates can be explained by urban discharges from neighboring agglomerations and the release of phosphorus trapped in large quantities in sediments. The atmospheric agents, wind and rain, also represent sources of phosphates especially when the river flow is weak [14].

The recorded concentrations remain below the Moroccan standard of 1 mg / L. These values then make it possible to classify these waters in the middle class with poor quality [13].

3.10 Ammonium

Ammonium is the product of the final reduction of nitrogenous organic substances and inorganic matter in water and soil. It also comes from the excretion of living organisms and the reduction and biodegradation of waste, without neglecting domestic, industrial and agricultural inputs.

This element exists in a small proportion less than 0.1 mg / L of ammoniacal nitrogen in natural waters. In the surface waters, it comes from nitrogenous organic matter, and gaseous exchanges between water and the atmosphere [15]. It is therefore a good indicator of the pollution of watercourses by urban effluents.

Usually, the ammonium values found during the flood period are clearly much lower than those of the dry period, especially downstream of the study area, thus reflecting the effect of the dilution and testifying to a good oxygenation of the waters. This causing oxidation of nitrogen in winter. But the analysis of the ammonium profile of the waters studied (**Tab.1**) shows that there is not a big difference between the two seasons: the contents vary between 2.44 mg/L and 2.82 mg / L in the flood period and between 2.54 mg / L and 2.81 mg / L in the dry period. This is certainly due to the rejections of the wastewater from oil mills (margine) during the month of December.

The values recorded in ammonium in the waters of Sebou river at the level of the Kariat Bamohamed area make it possible to place them in the bad class [13].

3.11. Nitrates

Nitrate (NO_3-) is the highest form of nitrogen in water. Their concentrations in natural waters are between 1 and 10 mg / L. However, their levels in untreated wastewater are low [15].The nitrate levels recorded (**Tab.1**) range from 12.5 mg / L to 20.18 mg / L and 1.45 to 2.28 mg / L respectively in flood and low water periods. The high levels of nitrates recorded in December 2014 may be due to the leaching of fertilizers used in agricultural soils located on the banks of Sebou river.

IV. CONCLUSION

In the light of cumulative results after monitoring the physicochemical parameters of the surface waters of the Sebou river in the Kariat Bamohamed (Midle Sebou) region, it was concluded that the quality of the water deteriorated both during the winter and the summer period [16-19].

Indeed, during the winter period, an increase in the values of ammonium, COD, BOD_5 and an acidic pH was noted. Discards of vegetable waters and leaching of fertilizers are held responsible in addition to the usual factors such as discharges of raw sewage from the cities of Fes and Kariat Bamohamed.

During the summer season, the low flow of the river, the increase of the water temperature and the activity of the microorganisms, explain the fact that the recorded values of the BOD_5 and the COD are more important than that recorded in winter. In addition, high values of electrical conductivity indicate excessive mineralization that exceeds the drinking norms [20].

ACKNOWLEDGMENTS

The authors acknowledge the Regional Office of Drinking Water Mkansa-Fez who allowed this physico-chemical monitoring.

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