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Seasonal Variation Of Water Quality In Oued Oum Er Rbia, Khenifra (Morocco)

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Abstract

Assessment of seasonal variations in surface water quality is an important factor to evaluate temporal impact on water pollution. This study evaluates the seasonal variation of physicochemical and microbiological quality of the Oum Er Rbia river in Khenifra city, Morocco. Water samples were taken from nine stations along the river (ST0-ST8) during the wet and dry seasons, and analyzed for physicochemical and microbiological parameters. These samples have been analyzed using the guidelines of the water quality assessment techniques. The results of the study show significant seasonal variation between dry and wet periods, majority of parameters values increase during the summer such as water temperature, mineralization (conductivity, hardness, alkalinity), BOD_5 and microbial indicators. This variation shows a clear influence of the effects of the organic pollution caused by the agglomerations along the river, making the impacts steeper and more felt during the dry seasons, and less felt during the rainy seasons.

Keywords: *Water quality; Seasonal variation; Physicochemical analysis; microbiology analysis;*

INTRODUCTION

Water quality is an always changing variable, affected by multiple factors. Starting from the terrain, human activities, climate changes and even seasonal changes. The parameters measured or tested using the same protocol in the same area of study often show different results when sampled and analyzed at a different season. The slight change in any factor impacting quality can have huge influence in the results. In fact, among the biggest factors influencing the water analysis results is seasonal variations.

Each season is related to a distinct physico-chemical and biological range that characterizes it. Thus, defining the properties of surface water, especially in continental climates where the seasonal variation is severe[1]. For example, higher temperatures during the summer catalyzes the development of microorganisms and speed up chemical and bio-chemical reactions reducing oxygen levels, and raising other parameters such as BDO_5[2]. However, in the cold rainy winters, the opposite effect occurs due to the extreme low temperatures, and the high dilution factor. The oxygen levels are higher and the biological activities are slowed, leading to relatively better readings in term of quality indicators[3].

Water resource monitoring and management is key to properly identify and even customize the treatments necessary in making surface water safe to use. This monitoring requires precise knowledge of seasonal patterns and fluctuations to function properly, and bear useful results that could be the foundation of exploiting surface waters. [4]. In fact, rivers, lakes, and reservoirs are more than just sources of water; They play a vital role for both natural ecosystems and anthropogenic activities [5].

This work provides a continuous quality monitoring of the Oum Er Rbia river in Morocco. The Oum Er Rbia River is one of Morocco's most important watercourses, ranking as the second largest in the country and noted for its abundant water resources. The river is distinguished by its substantial flow, which supports both hydroelectric power generation and extensive irrigation activities. Owing to its strategic geographical position, considerable water potential, and the coexistence of urban and agricultural zones within its basin, the Oum Er Rbia is particularly vulnerable to various forms of pollution. Increasing pressures from domestic discharges and agricultural practices further exacerbate the risks to its water quality and overall ecological balance. The quality monitoring involves many physico-chemical and biological parameters that were analyzed during the wet and the dry season.

International Journal of Environmental Sciences
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MATERIALS AND METHODS

Study area:

The study was conducted in the high-basin of Oum Er Rbia River, in the Khenifra Province, southwest of the Middle Atlas (fig.1). Oum Er Rbia River is one of Morocco's most important watercourses, ranking as the second largest in the country and noted for its abundant water resources. The river has a length of 550 km and presents an average flow of 105 m3/s of water [6]. A surface area of approximately 58.34 Km is considered in this study.

The study area is characterized by a Mediterranean climate known for warm/hot and dry summers and mild/cool and wet winters[7]. Within the wet periods experienced from October to April, minimum temperature values are usually 5°C, while in the dry season experienced from May to September, an average maximum temperature exceeds 45°C [8].

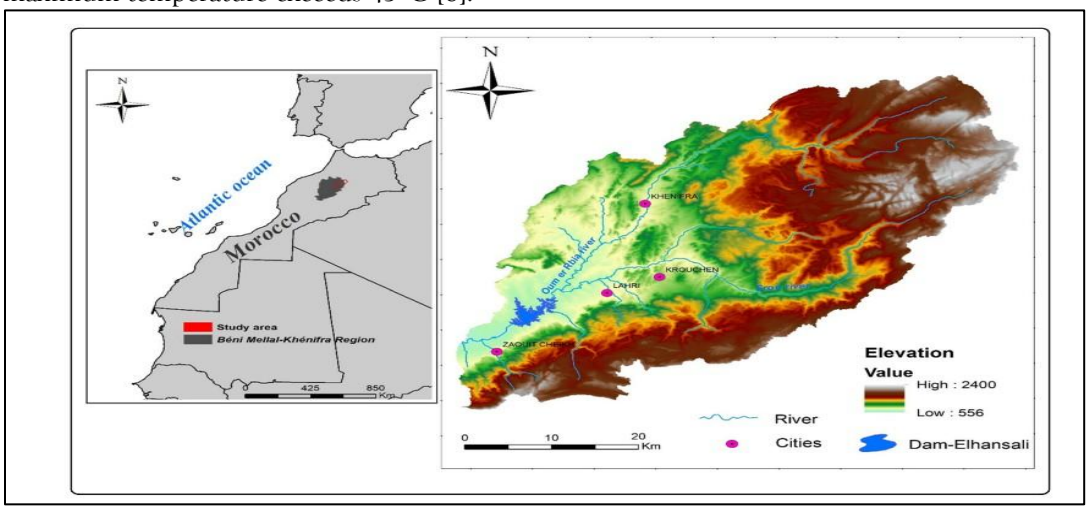

Fig.1: Location map of the high-basin of Oum Er Rbia

The area of study includes the sources of Oum Errabia river, where the water quality is of the highest rank, which can serve as a quality reference for other sampling stations. Human activities are limited to agricultural activities ranging from small to medium scales, as well as small agglomerations, with the exception of KHENIFRA being the biggest city in the study area. The pollution is limited to regular domestic wastewater. By avoiding industrial and more complex pollutions, the monitoring of the seasonal changes in the water can be more easily tracked throughout the multiple stations in the Oum Errabia river

Sampling and analysis:

The sampling sites (ST 0 to ST 8) were strategically selected along the Oum Er Rbia river (Fig. 2) from the source until right after Khenifra city, to study the spatiotemporal variability of water quality. The sampling was carried out during the wet season (from October 2024 to April 2025) and during the dry season (from May to September 2025). Samples were collected every two months following standard procedures to assure reliability and comparability of results according to the Moroccan Standards [9]. At each site, we used sterile bottles to collect water. Some of the parameters were measured in site such as temperature, pH, electrical conductivity (EC), dissolved oxygen (DO) using a portable multipara-meter meter (Hach HQ), meanwhile, the other parameters physicochemical and microbiological were analyzed in the laboratory. ST 0 is located in the source of Oum Er Rbia which is considered as a reference for the other stations. Stations ST1 to ST7 were distributed along the city (Fig.2), both upstream and downstream of potential pollution sources, in order to evaluate the influence of human activities on the river, as well as to observe the influence of seasonal changes on the impacts of pollution in water quality. Station ST 8, located further downstream, provides an overall picture of the river's quality after it has passed through the biggest city in the study area, Khenifra.

Tab.1: Location of the sampling stations

Station	Location	Altitude
ST 0	33°03'20"N 5°25'04"W	1220
ST 1	32°57'26"N 5°40'02"W	847
ST 2	32°56'46"N 5°39'58"W	836

ST 3	32°56'38"N 5°39'46"W	835
ST 4	32°56'37"N 5°39'45"W	835
ST 5	32°56'36"N 5°39'45"W	835
ST 6	32°55'41"N 5°40'26"W	825
ST 7	32°55'35"N 5°40'24"W	826
ST 8	32°54'12"N 5°41'16"W	805

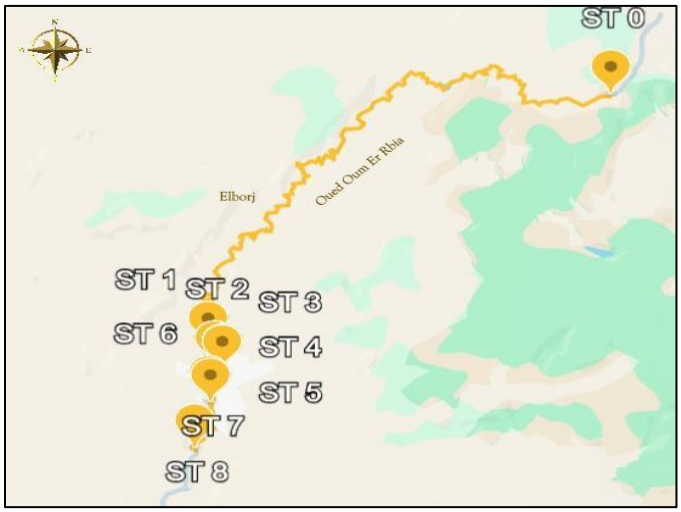

Fig.2: samples location in Oum Er Rbia river

The physicochemical and microbiological parameters studied in the Oum Er Rbia river during the wet and dry season are typical quality indicators. The analysis done and the protocol followed are all represented in

Tab.2: The water quality parameters and their analytical method in this study.

Parameter	***Abbreviation***	***Unit***	***Measuring equipment and method analysis***
Temperature	T°C	° C	portable multipara-meter meter (Hach HQ)
Electrical Conductivity	EC	µS/cm	portable multipara-meter meter (Hach HQ)
Potential Hydrogen	pH		portable multipara-meter meter (Hach HQ)
Dissolved oxygen	DO	mg/L	portable multipara-meter meter (Hach HQ)
Total Hardness	TH	°F	Titrimetry, Complexometry with EDTA black of eriochrome.
Complete Alkalimetric Title	CAT	°F	Titrimetry with Hydrochloric acid
Biochemical Oxygen Demand, 5days	BOD_5	$Mg0_2/L$	Aerobic digestion of organic matter, KOH for CO_2 adsorption.
Sulphates	$SO4^{2-}$	mg/L	Nephelometric method with barium sulphate
Nitrites	NO_2^-	mg/L	Zambelii method
Orthophosphates	PO_4^{3-}	mg/L	Colorimetry
Total coliforms	TC	UFC/100ml	Inoculation method
Fecal coliforms	FC	UFC/100ml	Inoculation method
Escherichia colis	E.Colis	UFC/100ml	Inoculation method

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https://theaspd.com/index.php

RESULTS AND DISCUSSION

Tab.3 presents the results obtained after analyzing every of the samples periodically and following the same protocol. The values variations between wet and dry periods are clear evidence of the seasonal changes impact on the physicochemical and microbiological parameters of the river's water quality in the studied area.

Tab.3: Water quality parameters and measurement methods.

Parameters	Wet Saison			Dry Saison			NM
	Min	Max	Average	Min	Max	Average	
Temperature	9.3	14.26	11.17	18.5	27.9	22.46	20-50
Electrical Conductivity	1.61	3	2.29	2.1	4.49	3.30	1300-2700
Hydrogen potential pH	8.07	8.73	8.24	8.1	8.93	8.31	6.5-8.5
Dissolved Oxygen	8.24	10.42	8.82	5.12	7.5	6.10	7.0-5.0
Total Hardness	11.54	34.9	27.29	15.5	40.2	28.22	
Complete Alkalimetric Title	13.55	65.89	33.98	15.5	63.4	30.31	
Biochemical Oxygen Demand, 5days	1	18	8.67	2	45.3	11.52	5.0 - 10.0
Sulphates	50	75.05	65.71	45	69.5	56.63	<100
Nitrites	0	0.12	0.054	0	0.12	0.046	0.5
Orthophosphates	0	4.25	2.46	0	5	1.88	
Total coliforms	685	1200	914	855	1750	1303	50-5000
Fecal coliforms	70	187	136.94	100	220	156.11	20-2000
Escherichia coli	76	140	100.83	81	200	133.48	200-400

Temperature:

During the dry season, the temperature rises intensely, reaching values that can exceed 28°C, compared to 14°C during the wet season. The lowest temperature values were recorded at ST0, located upstream, whilst the highest values recorded during the dry period at the stations ST2 to ST7 as indicated in Fig 3, which are located in the urban area of KHENIFRA. These differences can be explained partly by the variation in altitude between the source station (ST0) and the downstream sites, and partly by the influence of the hot and dry summer climate, which enhances thermal heating of the river.

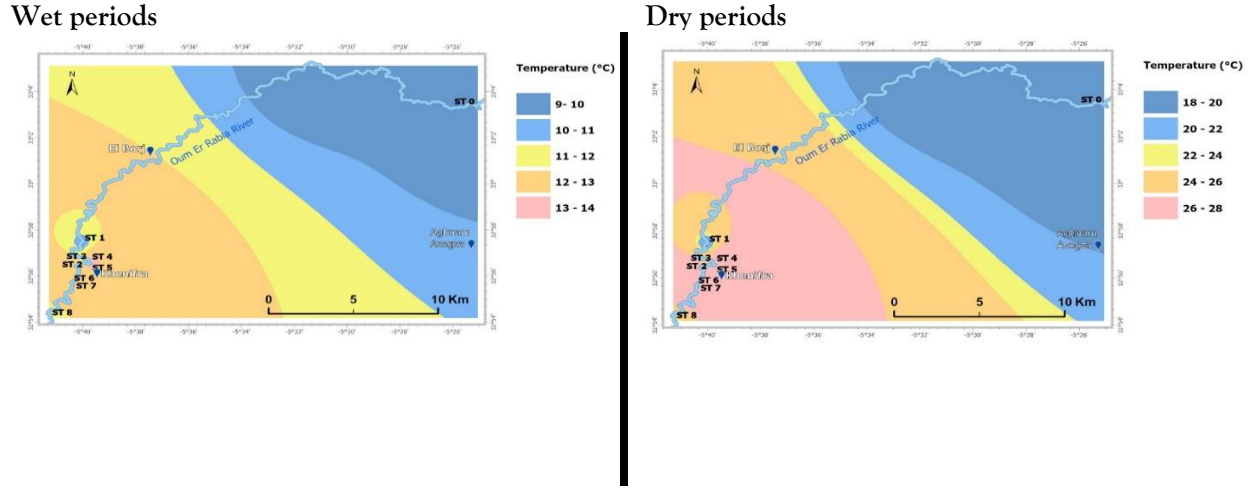

Fig 3: Temperature variation in wet and dry season in Oum Er Rbia river

Hydrogen potential pH:

The pH values of the river water of Oum Er Rbia appeared to be relatively stable in both seasons in Fig 4, consistently reflecting alkaline conditions. Those alkaline values are due to the calcious nature of the terrain,

the abundance of CACO3 increases the pH of the water. This effect is particularly evident at ST0, located in the mountainous upstream area.

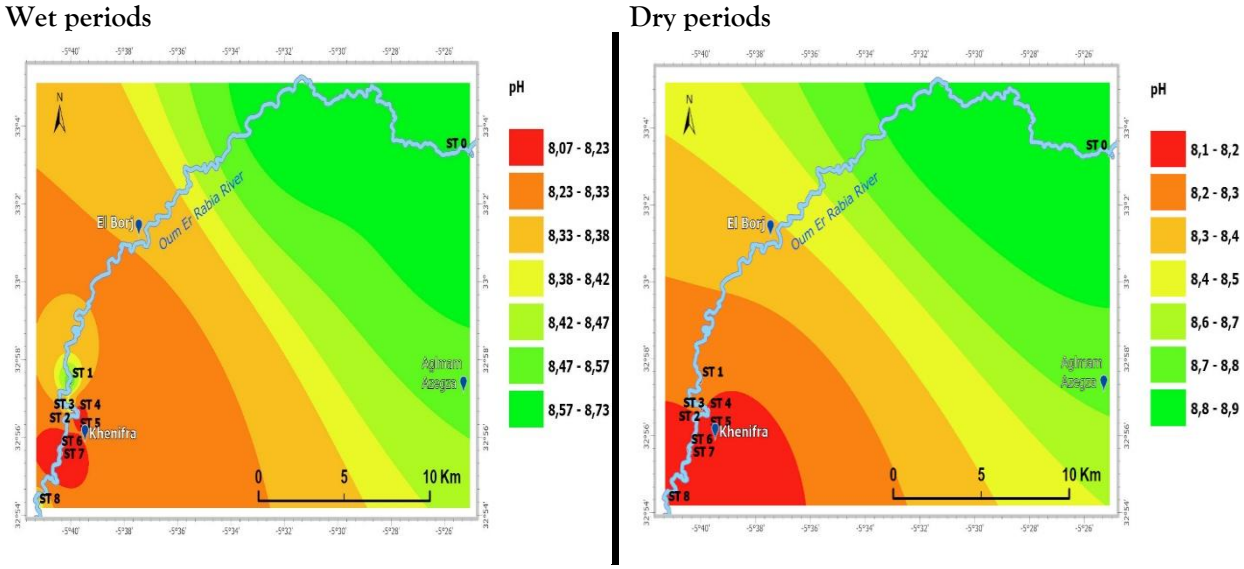

Fig 4: pH variation in wet and dry season in Oum Er Rbia river

Electrical Conductivity:

The electrical conductivity results marked an increase during the dry season, reflecting the higher concentration of minerals in the water. However, the EC values show clear decline during the wet period as indicated in Fig 5, this phenomenon can be correlated to the higher dilution rate due to the rainy season making the concentration of minerals in the water lower.

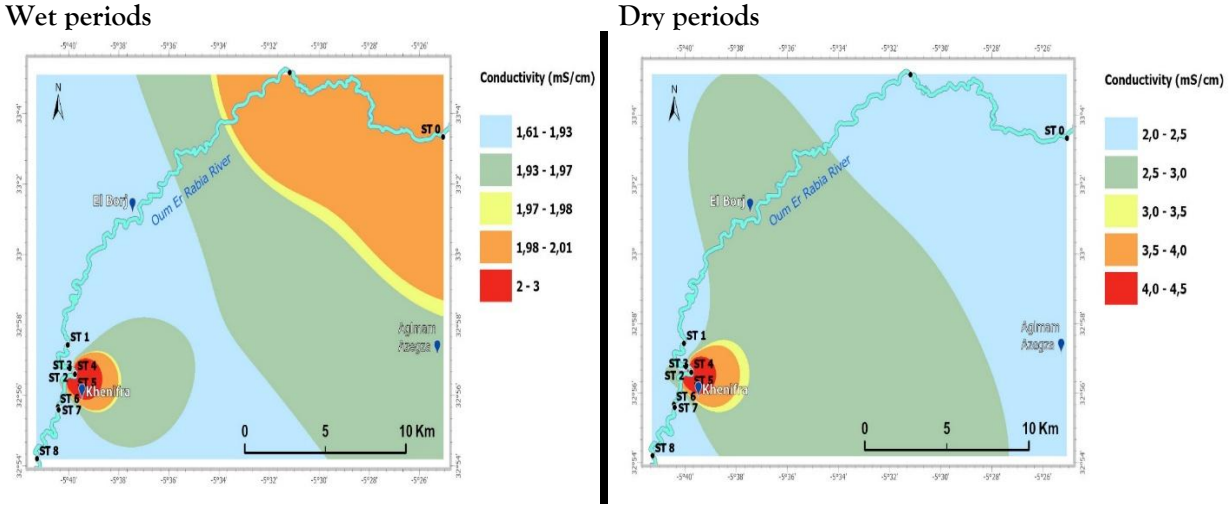

Fig.5: Electrical Conductivity variation in wet and dry season in Oum Er Rbia river

Dissolved Oxygen:

Dissolved oxygen (DO) values of the water samples in the Oum Er Rbia river indicated in Fig 6, are ranging from 8 to 10.5 mg/l in winter reflecting an excellent quality in terms of water quality indicating that each of the stations is not subject to any heavy pollution influence. During the dry season, dissolved oxygen values ranging from 5 to 7.5 mg/l reflecting the remarkable influence of summer on the dissolved oxygen. The brutal seasonal change influenced even the impact of the organic pollution, as temperature can be a direct catalyzer in the microbial proliferation, leading to much higher oxygen consumption in the presence of abundant organic matter issued from the city sewage.

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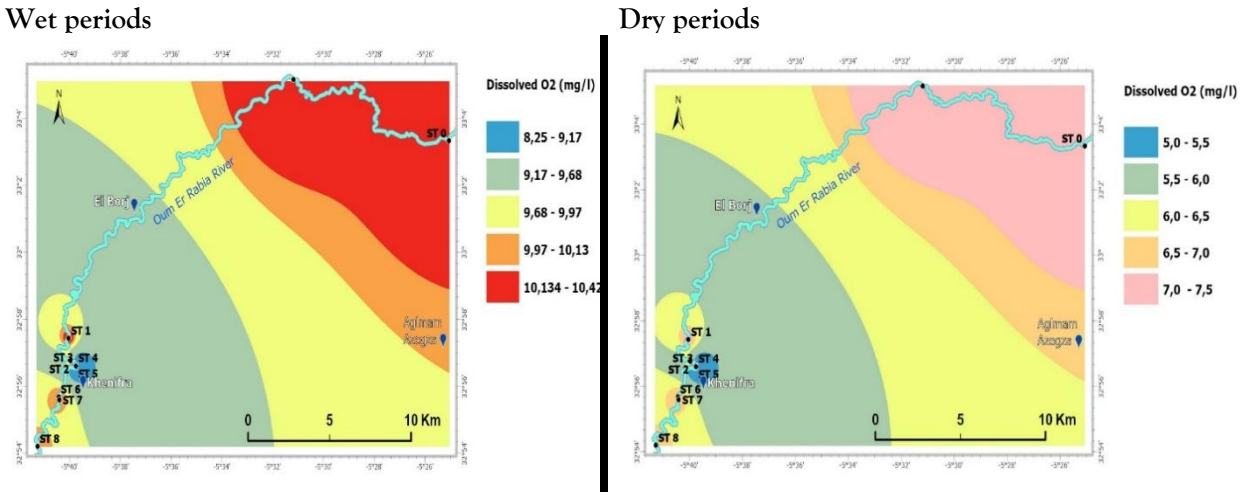

Fig.6: Dissolved oxygen variation in wet and dry season in Oum Er Rbia river

Total Hardness:

The total hardness values in Fig 7 show seasonal variation between wet and dry seasons. Values are generally lower during the wet season ranging from 10 to 35°f. As the river crosses Khenifra city, total hardness increases due to urban and agriculture activities, as well as the calcareous terrain. In contrast, during the dry season, hardness values increase reaching 40°f. This increase can be explained by the reduced dilution rate and the higher evaporation rates.

Overall, the values remain relatively high in both wet and dry periods, which can be explained by the geological characteristics of the Oum Er Rbia watershed.

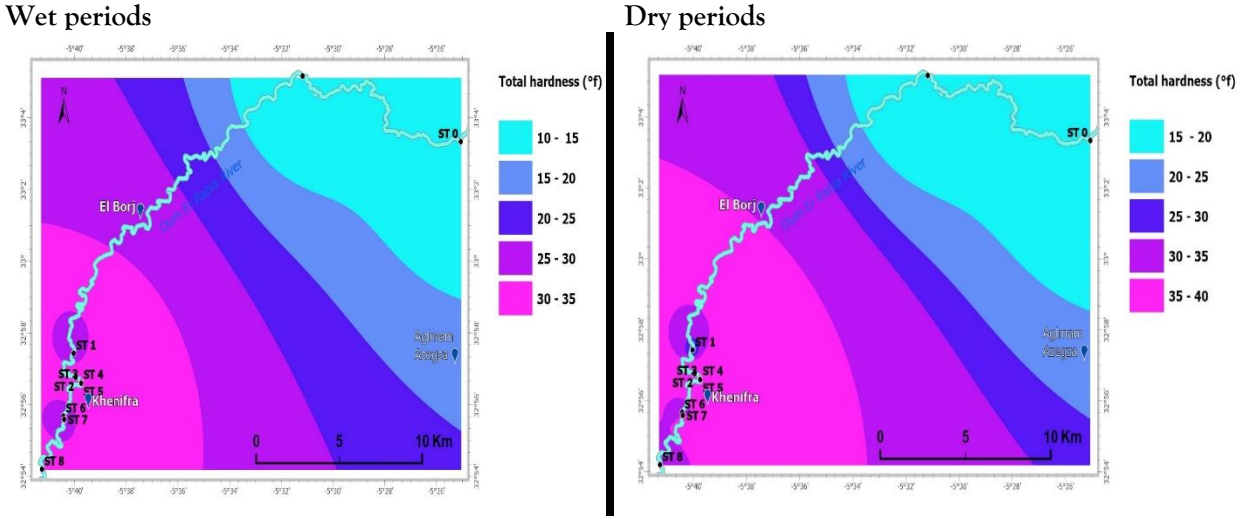

Fig.7: Total hardness variation in wet and dry season in Oum Er Rbia river

Alkalinity:

Alkalinity values represented in fig.8 range mostly between 20 to 35°f during the wet season and increase in during the dry season to range between 25 to 40°f. An elevation in values were detected in ST 2, ST 3 and ST 4 in both seasons especially in the dry periods approaching 60°f, reflecting the influence of urban discharges.

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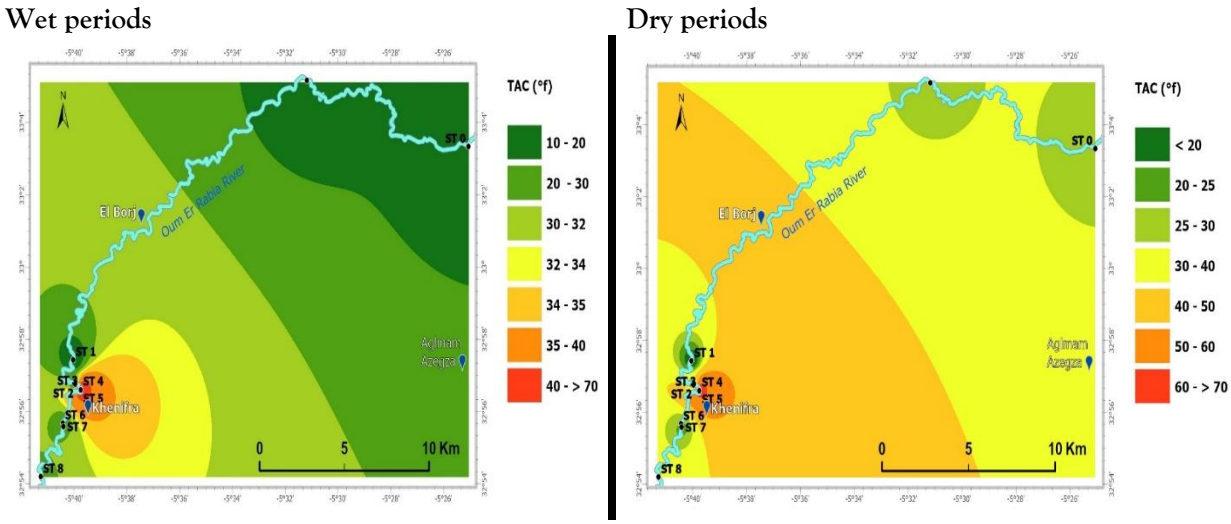

Fig.8: Complete Alkalimetric Title variation in wet and dry season in Oum Er Rbia river

Biochemical Oxygen Demand:

Biochemical Oxygen Demand over five days (BOD_5) is an indicator to quantify the organic pollution in river water. Values of BOD_5 in Fig.9, show a noticeable seasonal variation, with lower values during the rainy season due to dilution and higher river flow. During the summer with the increase of organic pollution and the diminution of river flow; the BOD_5 values are higher, especially downstream the river. This indicates a greater consumption of dissolved oxygen by microorganisms breaking down organic matter, which can threaten aquatic life by reducing oxygen availability.

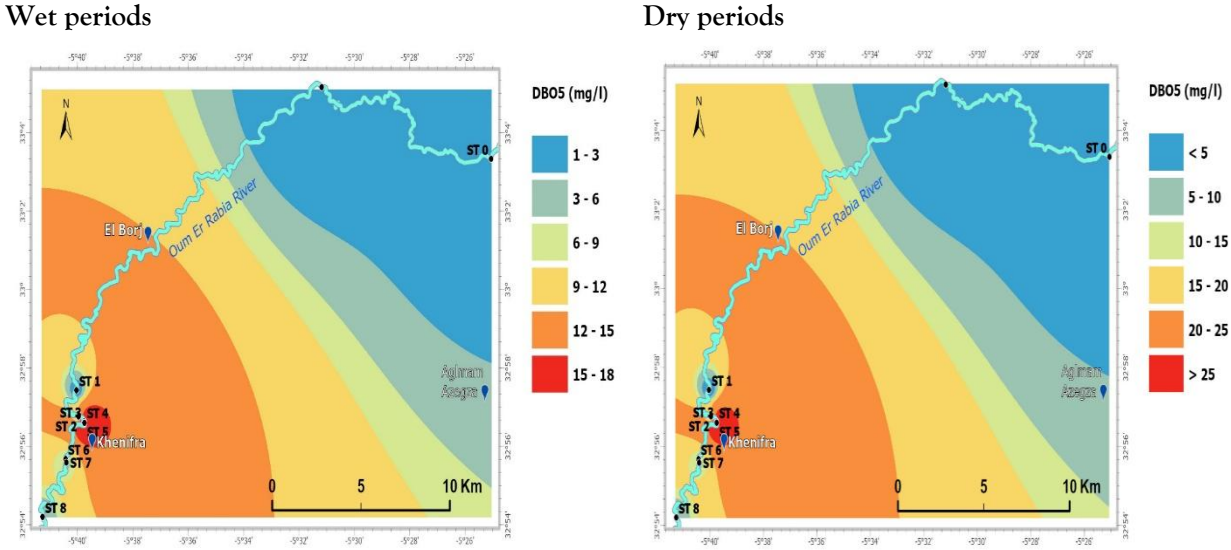

Fig.9: Biochemical Oxygen Demand variation in wet and dry season in Oum Er Rbia river

Sulphates:

The concentration of Sulfates in Fig 10 varied in the range of 50–75 mg/L in the rainy period and 45–70 mg/L in the dry period. Those values are considered moderate values according to the Moroccan Standards (<100) for surface water. Sulfates in water can originate from the decomposition of organic matter in soils, the leaching of sulfate-based fertilizers, and various anthropogenic sources, such as sulfur-containing compounds present in domestic wastewater [9], [10].

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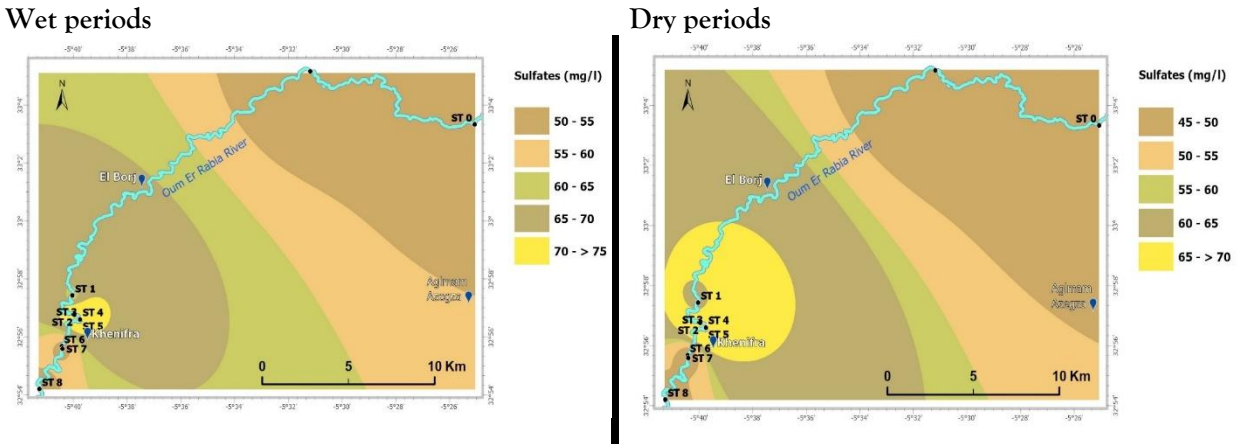

Fig.10: Sulphates variation in wet and dry season in Oum Er Rbia river

Nitrites:

Nitrite concentrations in the study area represented in Fig 11, ranged from 0 to 0.07 mg/l in both wet and dry season. These values are considerate low compared to the guideline limits for surface water quality. The nitrites are known to be an unstable form of nitrogen, as they tend to quickly transform into nitrates.

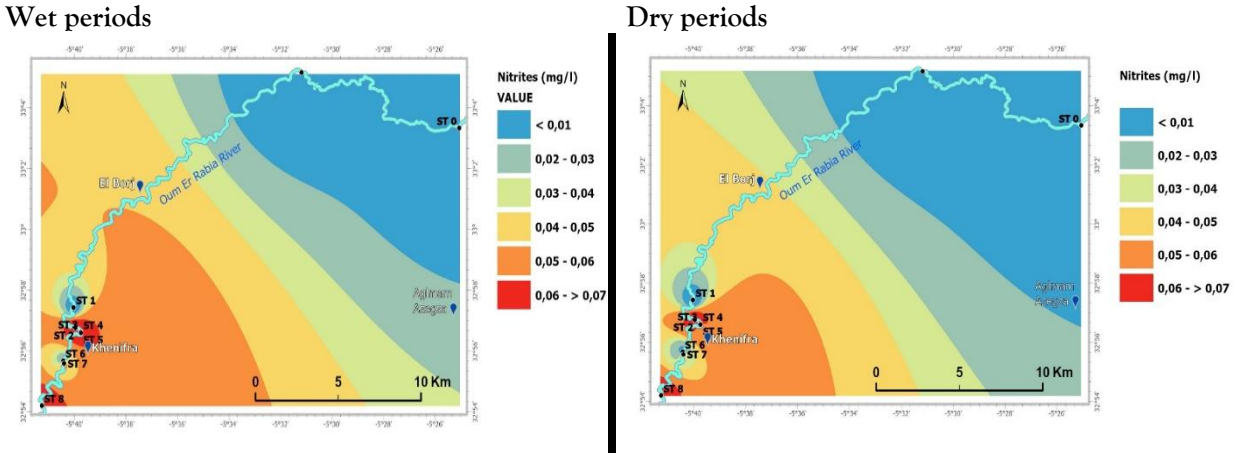

Fig.11: Nitrite variation in wet and dry season in Oum Er Rbia river

Orthophosphates:

Orthophosphates are generally not dangerous to aquatic life, and they are frequently employed in fish farming to boost planktonic biomass[11]. When present in significant quantities, they may cause eutrophication[12]. In the study area, Fig. 10 indicates low orthophosphate concentrations at ST 0, the upstream reference site, while higher values are observed downstream, particularly after the river passes through agricultural areas. This increase is likely associated with runoff from fertilized fields, highlighting the influence of human activities

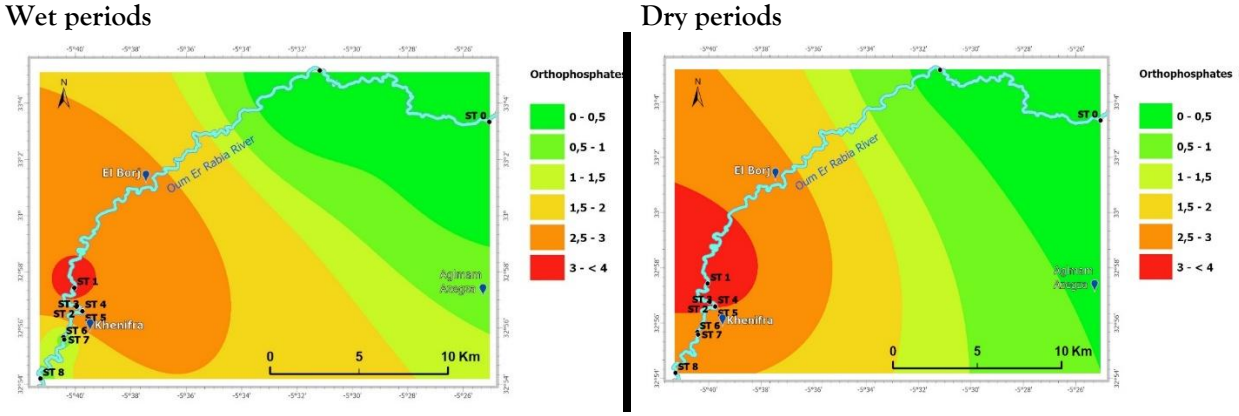

Fig.12: orthophosphates variation in wet and dry season in Oum Er Rbia river

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Vol. 11 No. 25s,2025
https://theaspd.com/index.php

Total coliforms:

Total coliform counts in the river present a significant seasonal variation, with highest values registered during the dry season, reaching 1800 CFU/100ml, in comparison to 1300 CFU/100ml in the rainy season as indicated in Fig 13. These values considered very high, signifying a microbial contamination, specially at stations located in the central area of Khenifra city. The seasonal variation of the coliform count can be explained by the role of temperature as catalyzer, as mentioned before, it can also be traced back to the increase in the population and human activities during the summer in the cities and small agglomerations.

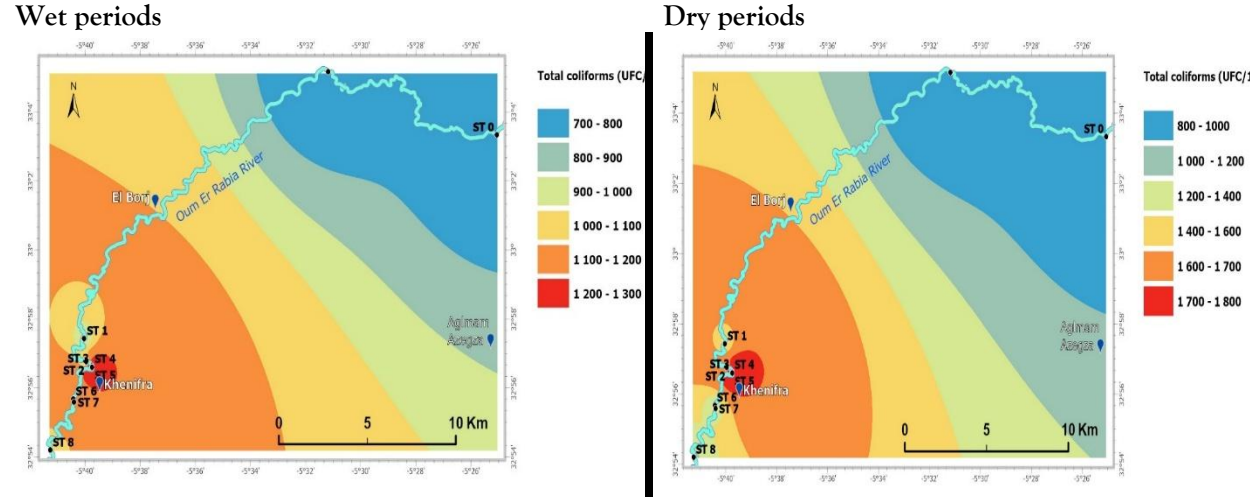

Fig.13: Total coliforms variation in wet and dry season in Oum Er Rbia river

Fecal Coliforms:

Fecal coliform concentrations in the Oum Er Rbia river reveals clear seasonal variations as represented in Fig 14. During the wet period, concentrations of fecal coliforms are lower compared to the dry periods. At the upstream station ST 0, fecal coliform values were generally lower, in opposite, downstream around ST2 to ST7, higher values were observed in both season reflecting the impact of anthropogenic activities and wastewater discharges which diminishes the quality of surface water.

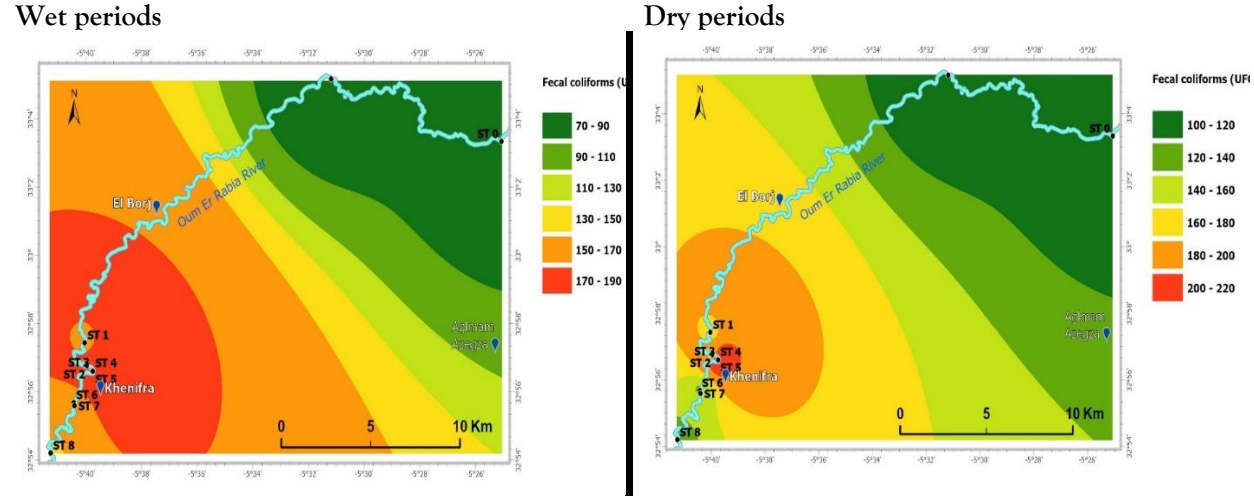

Fig.14: Fecal coliforms variation in wet and dry season in Oum Er Rbia river

Escherichia Coli:

Using conventional microbiological methods, Escherichia Coli results of water samples in the Oum Er Rbia river presented in Fig 15, are showing the lowest values of 80 CFU/100ml at dry season and 70 CFU/100ml at wet season in ST 0. The values increase downstream the river to almost reach 140 CFU/100ml in the wet season and 200 CFU/100ml in the dry season. It is notable that the maximum values were located in ST 3 and ST 4 which are near a domestic sewage discharge.

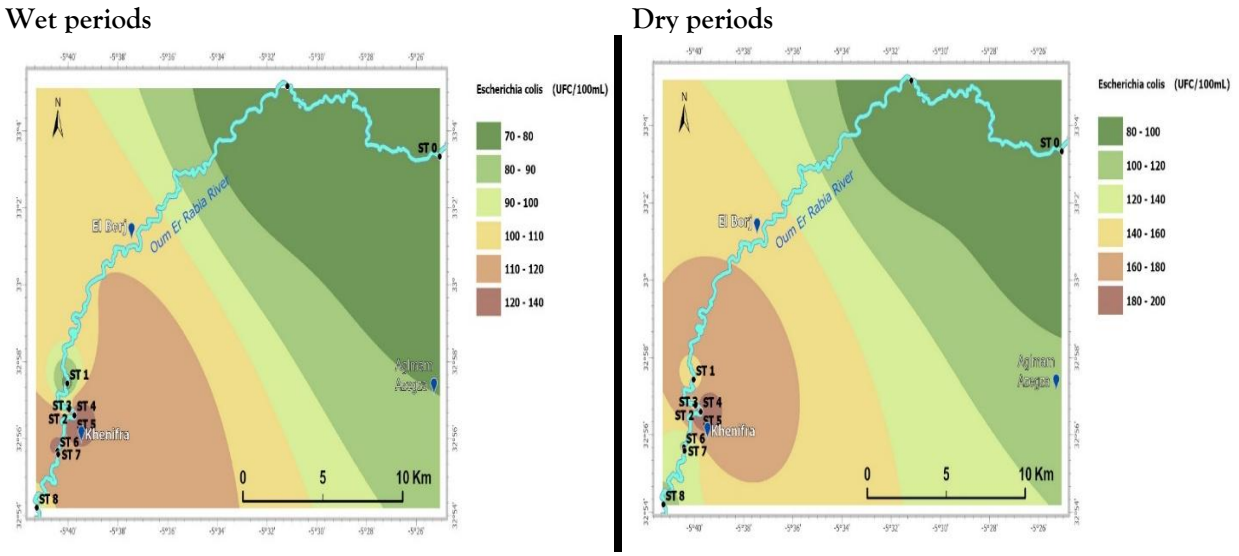

Fig.15: Escherichia Coli variation in wet and dry season in Oum Er Rbia river

CONCLUSION

The Assessment of surface water quality is a lifelong procedure, considering environmental circumstances may change over time as a result of various factors such as climate change, and pollution. Protecting and improving the quality of these resources is a necessity in the last decades. This study evaluates the water quality of the Oum Er Rbia river by analyzing physicochemical and microbiological parameters considering spatial and seasonal variations. According to the obtained results, the spatial distribution from ST0 to ST 8 downstream the river, ST0 represents the natural reference site with almost no anthropic pollutants. From ST1 to ST8 with higher values of conductivity, total hardness, alkalinity, BOD_5, orthophosphates, fecal coliforms, and Escherichia coli, reveals that anthropogenic activities, agriculture and terrain nature are the main factors causing a deterioration of water quality of Oum Er Rbia river. Furthermore, the brutal changes of the weather conditions, the peak rising of the temperatures in summer which is marked by hydrological stress, amplifies the values of most parameters, rising the degradation of the river's water quality by increasing the BOD_5 values indicating stronger organic pollution, fecal coliforms, E. coli, and total bacteria levels can double or even triple compared to winter, aggravating fecal contamination. In opposite, during the winter, higher river flow combined with lower temperatures, increases the dilution capacity of the water, limiting the influence of contaminants and preserving relatively good quality.

The results of the present study highlights that the dry period significantly worsens water quality in Oued Oum Er-Rbia downstream of KHENIFRA, compared to winter. This study can be useful in the monitoring and control of river water quality in different climate patterns.

Conflict of interest

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

Availability of data and materials

The data that support the findings of this study are available at reasonable request from the corresponding author.

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Availability of Data and Materials
All the data presented in this work is available at reasonable demand, please contact the corresponding author for any additional information.

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