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Assessment of the Physicochemical Quality of Water in the River Oum Er-Rbia- Morocco

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Abstract: *This study is based on samples taken during the periods January, June, November of the year 2014 and the month of March of the year 20015 at the surface water level of the Oued in different stations along a section extending from the dike of sidi daoui to the mouth of the estuary. These samples were analyzed using the water quality assessment techniques described by Rodier (2009) and the recommendations of the World Health Organization. This study concerns the analysis of physico-chemical parameters (T °, pH, electrical conductivity, PO_4^{3-}, Na^+, Ca^{2+}, Mg^{2+}, K^+, SO_4^{2-}, Cl^-, NO_2^- and NO_3^-). The results of the analyzes show that the waters of this watercourse are divided into two groups, the first including stations S1 and S2 characterized by low natural mineralization and concentrations below WHO recommended standards (WHO, 1984) And Moroccan norms (MATEE, 2002) of the various parameters generally indicating that the waters of this watercourse are of a good quality..On the second ring, the rest of the stations are characterized by mineralization and grades Of the various very important parameters and exceed the limit values set by the Moroccan standards for water intended for irrigation.*

I. Introduction

The evaluation of the physico-chemical quality of water to attract the attention of several researchers in Morocco. Indeed, H. TAOUIL et al evaluated the physico-chemical quality of surface waters on the one hand and groundwater on the other (1-3). These authors have shown that the behavior of certain parameters descriptive of the physico-chemical quality of surface waters does not risk disrupting the aquatic life of the site studied. Thes Estuaries are particularly vulnerable to permanent pollution: they receive different types of waste water from urban wastewater, industrial effluents often loaded with organic debris and or pollutants of agricultural origin (fertilizers, pesticides). In addition, some estuaries with strong marine influence exhibit a hydrodynamic circulation varying according to the tidal cycle, which could constitute an obstacle to the evacuation of pollutants at sea and, consequently, to the restoration of the estuary's salubrity.The estuary of the Oum Er-Rbia like all the other estuaries of the country, does not escape this description. It is bordered by the town of Azemmour which continues to grow and whose estuary constitutes an important weir of domestic wastewater. On its borders there are several garbage dumps, an industrial unit of agro-food nature and an important agricultural activity under greenhouses. These various sources of pollution condition the physicochemical quality of the waters and generate metallic pollution of its compartments (sediments, algae, fish ...) by bringing a large number of organic waste, solid waste, pesticides, fertilizers and Detergents. They also condition its biological quality by making the environment conducive to the proliferation of different pathogenic germs (coliforms) or parasites (helminthes). In the Oum Er Rbia estuary, little work by Kaimoussi (1996) and Zourarah (2002) partially addressed the impact of pollution on the physicochemical and mineralogical quality of the compartments of this ecosystem. The objective of this work is to study the influence of the discharge of the waste water of the city of Azemmour and the agricultural and industrial rejections on the quality of the waters of wadi estuary for four seasons. The study covers a 20 km stretch between the sidi Daoui embankment and the Oum Er-Rabia mouth.

II. Material And Methods

2-1Choice of stations

Sampling of wadi water samples was carried out during rural counts during two winter and low water periods (January and June of 2014) and the two other periods of November 2014 and March 2015 In order to determine the average concentrations of the physicochemical parameters and to characterize the quality of the

Oum Er-Rabia oued, ten stations were retained on its main flow axis, their choices result from a compromise between The possibility of sampling and the need to account for the spatial organization of the wadi. These stations are noted as follows.

-S1: Station located before sidi dawi dam at 15 km from the mouth.-
-S2: station located on sidi dawi dam.-
-S3: Station located between sidi dawi dam and station 4.-
-S4: station receives waste water from cultivated fields.
-S5: station located on wadi between station 4 and station of industrial unit –Unimer-
- S6: Station located on the wadi and in front of the waste water of the industrial unit-Unimer
-S7: station receives the waste water from the main collector C1.
-S8: station on oued located in the vicinity of the collector C2.
-S9: Station directly receives waste water from collector C3.
-S10: Station located at the mouth of the estuary.

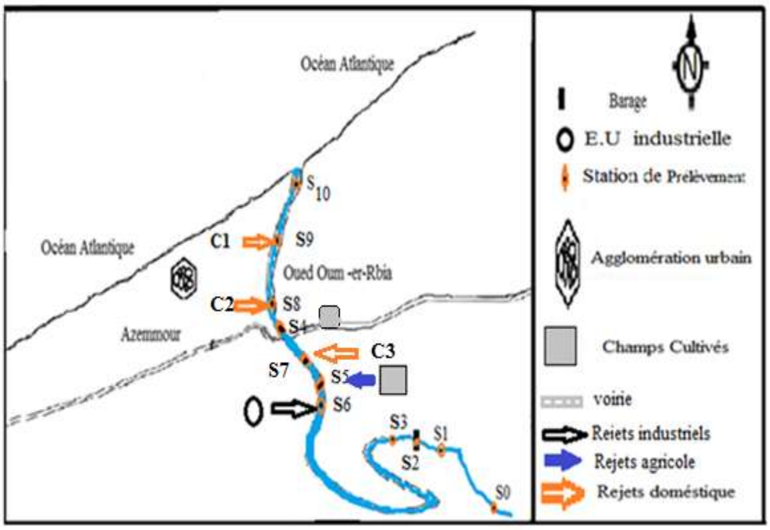

Fig1: location of study stations on the Umm Rabie river.

2-2 Results and Discussion

2-2-1-Physical Factor

A) Temperature

Water temperature is a parameter of major importance in the life of aquatic ecosystems. It has an influence on several physical, chemical and biological processes (4). It controls the evolution and transformation in the aquatic environment of many chemical factors including dissolved oxygen, an essential factor for aquatic organisms. The water temperature of the different stations studied varies between 24 ° C and 26 ° C for the low-flow companion and between 14 ° C and 20 ° C for the winter companion fig (2). The maximum values oscillate around 26 ° C, remain below 35 ° C, considered as the limit value recommended by the NMEDI. From a point of view to the spatial variations, no significant difference was observed

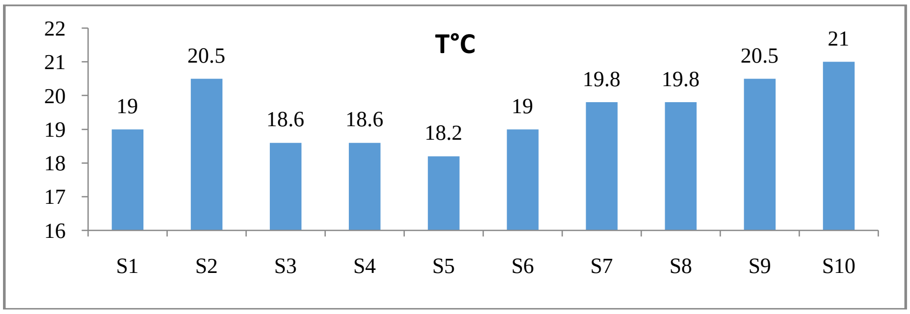

Fig. 2: Spatial evolution of mean values of temperature

The discrepancies recorded are in fact due only to the daily time difference between the different sampling points, which is why the spatial profile does not show any significant difference between the different stations. The mean values are between 16.77 ° C and 25.35 ° C and are linked to local conditions (climate, duration of sunshine, flow) [5].

B) pH

The pH (hydrogen potential) measures the H^+ ion concentration of water and thus translates the balance between acids and bases on a logarithmic scale from 0 to 14. This parameter conditions a large number of physicochemical equilibria. It is bound to the buffer system developed by carbonates and bicarbonates. It depends on the diffusion of carbon dioxide from the atmosphere, the balance of respiratory and photosynthetic metabolisms (6) as well as the origin of the waters, the geological nature of the medium traversed, wastewater discharges, etc. (7). It is indissociable from the values of temperature, salinity and CO_2.Its values are between 6 and 8.5 in natural waters (9). The Moroccan standard has set an interval for the pH of water between 6.5 and 8.5 as maximum and minimum permissible values. The pH values observed during the study periods showed no significant variations between the stations and remained between 7.59 and 8.4 (fig 3).

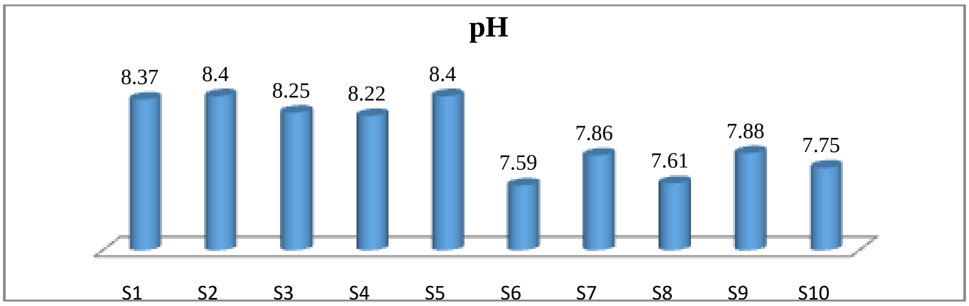

Fig 3: Spatial evolution of mean pH values

These values have remained neutral, and slightly basic. This alkalinity is due to the buffering effect of estuarine waters. However, this stability of neutrality can be explained by a buffer system developed by carbonates and bicarbonates [10, 11, 12, 13]. The variation in pH between the countryside does not usually exceed one pH unit for the different stations surveyed. The pH values found in the different stations studied during our seasonal cycle are acceptable according to the Moroccan standard and do not present a danger to the fauna and flora. These variations are not easy to interpret because they are the result of many of the physical and biological factors that are difficult to demonstrate. The pH ranges that are directly lethal to fish are those below 5 and those above 9 [14].

2-2-3 Conductivity

Conductivity is a measure of the ability of water to conduct electric current. The conductivity increases in parallel with the increase in dissolved minerals (ions) and may indicate the presence of other contaminants. It is part of the parameters used to determine the general quality of a water (15), consider that the electrical conductivity makes it possible to appreciate the degree of mineralization of the water, but should not be considered alone during the study of Unknown aquifers. Sometimes fluctuations in conductivity values are largely explained by changes in hydrological regime.

The results presented in our study (fig 4) show that the recorded values oscillate between 0.48mS / cm and 51.3mS / cm during the study periods. The strong mineralization observed at stations S3 to station S10 is due to influences of marine origin during high tides, the same observation was recorded in the work (13). An appreciable ion enrichment of the married waters which will consequently influence the values of the mineralization.

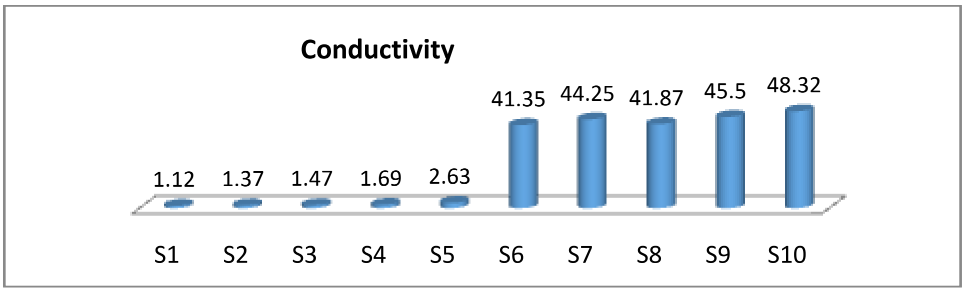

Fig 4: Spatial evolution of mean conductivity in ms / cm

Nevertheless, the waters of these stations have average conductivity values which are well above the limit value for irrigation (12 ms / cm). According to Moroccan standards, these values are also higher than the drinking water standard 2.7 us / Cm as the maximum permissible value. Consequently, the values obtained are unfavorable for a normal ecological balance. At the stations S1 and S2 the mean values of the conductivity are low by contribution to the other stations of the wadi, the waters of these two stations flow in a sloping manner from top to bottom, consequently these waters are not contaminated by the Waters of the tide.

Chemical Factors

1-2-2 Calcium Hardness (Ca)

Calcium is present in all natural waters and contributes significantly to their hardness. Exceptionally hard water can affect the operation and service life of plumbing systems and household appliances..

Calcium plays an essential role in the formation of skeletons and shells, and in cellular permeability phenomena it is concentrated by organisms from water or food. It can not in any case pose problems of potability, the only domestic disadvantage related to a high hardness is scaling. On the other hand ; Very soft waters can lead to pipe corrosion problems [17]. Mean catenas from Ca (fig. 5) in all stations oscillate between 52.95 mg / l and 596.25 mg / l, there is a slight variation in concentration between the different stations during the study period, The time factor has no significant effect. An increasing gradient of the concentration is shown, a significant difference is observed between the mean levels measured at the two upstream stations (S1 and S2) and the downstream stations, which explains the marine and anthropogenic effect.

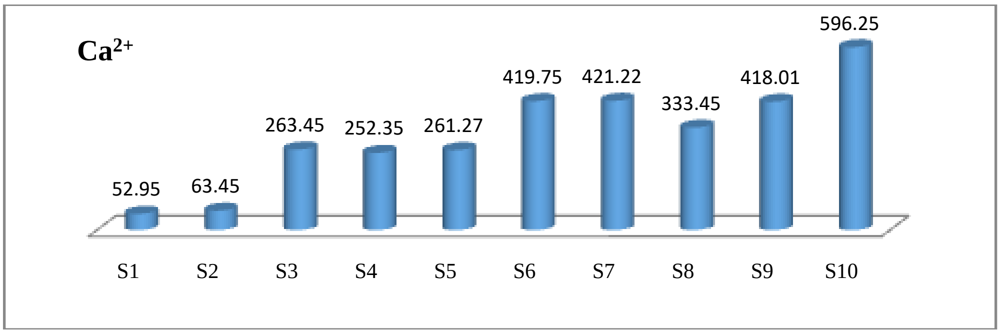

Fig 5**:** Spatiotemporal evolution of calcium hardness in mg /l

The highest grade is recorded at the mouth station, which illustrates the influence of marine waters. The waters of stations S6, S7, S8, S9 and S10 have an average content greater than 270mg / l, corresponding to the guide value set by the WHO standards, whereas the values measured in the other stations S1, S2 , S3, S4 and S5 comply with the OMS.

2-2-2 **Magnesium (Mg)**

Magnesium is present in all natural waters. It is an indispensable element, in small quantities, to all living organisms. Magnesium contributes significantly to the hardness of the water. Water that is too hard can affect the operation and life of a plumbing system and appliances. Fig (6) shows some heterogeneity in Mg concentrations. However, The mean extreme values in Mg recorded at the stations S1 and S2 are successively of the order of 49.61 and 47.86 mg / l, these two stations are the lions of all kinds of anthropogenic pollution from which their enrichment in Mg could be linked to the nature Lithology of the watershed. Note that according to the surface water grid and Moroccan standards (50mg / l) these waters of S1 and S2 are attributed to the excellent class. A spatio-temporal analysis of the Mg content shows that the waters of stations S3 to S10 have higher concentrations and are between 424.83mg / l and 2110 mg / l, this increase may be due to soil leaching caused by (16), and to the residues discharged at these stations by domestic, agricultural and industrial collectors.

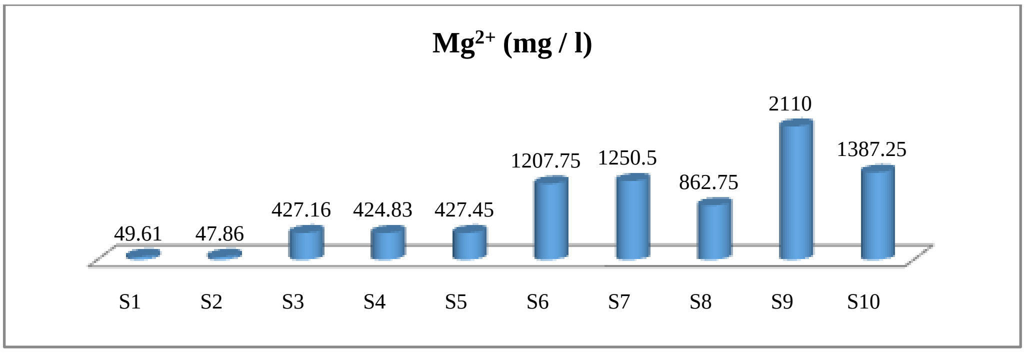

Fig 6**:** Spatial evolution of the mean contents of magnesium ions in mg / l

The values found in the different stations studied (S3 to S10) during our companions exceed the value indicated by the OMS (50mg / l), which makes these waters of bad qualities.

3-2-2 Potassium (K)

Potassium is naturally present, but the most frequent sources of potassium in drinking water are water treatment systems, such as ion exchangers (water softeners) that use chloride Of potassium. It is an indispensable element, in small quantities, to all living organisms. The harmful effects associated with a high concentration of potassium in drinking water are unlikely in healthy individuals. Potassium, on the other hand, can have adverse effects on people with certain diseases (eg, people taking heart, kidney, pain, and HIV medications). The waters of stations 1 and 2 have low average contents in this element, these contents range between 2.64 and 2.86 mg / l and comply with the OMS standard of 12 mg / l.A significant increase in concentrations was observed at the other stations (fig 7).

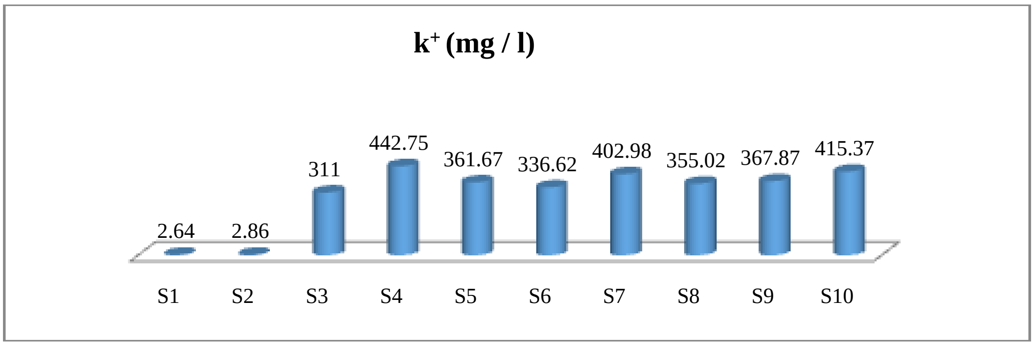

Fig 7: Spatial evolution of average potassium ions content in mg / l

Then the spatial factor is present, the values oscillate between 311 and 442.75 mg / l. This enrichment of stations prospected by potassium could be anthropogenic [18]. Thus the levels found are well above the limit value set by the OMS. At station S4, a maximum level was detected, however the massive use of fertilizers rich in potassium evidence this elevation.

4-2-2 **sodium (Na)**

It is an indispensable element, in small quantities, to all living organisms. A high concentration of sodium can give the water a salty taste. Sodium in drinking water can have adverse effects on the health of people on a salt-depleted diet. In nature, the sodium contents are relatively constant and vary only in the order of a few tens of milligrams per liter, independent of the leaching of the geological formations containing sodium chloride. Salt may be derived from the decomposition of inorganic salts such as sodium and aluminum silicates, marine fallout and salt water from aquifers [19]. Sodium is present in all stations sampled with average contents ranging from 207.85 to 15147 mg / l (fig 8).

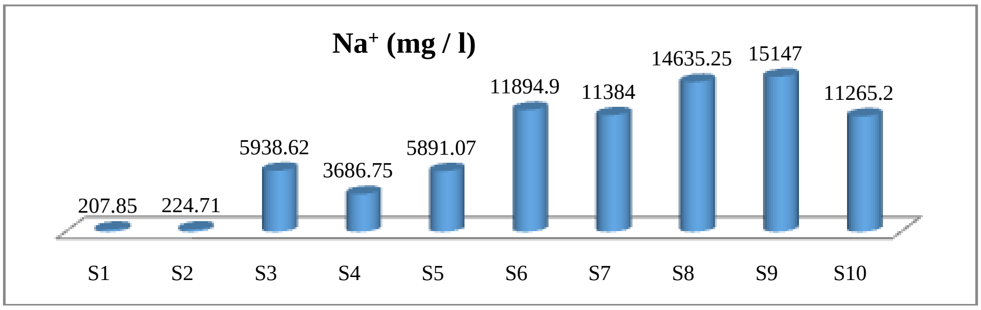

Fig 8: Spatial evolution of average sodium ions content in mg / l

According to the standards set by the OMS. (150 mg / l). The waters of these stations have a high sodium content. Consequently, the waters of ouadi Oum Er-Rabia are classified in the class (very bad), according to the simplified grid for the assessment of the overall quality of rivers waters in Morocco. Moreover, an increasing gradient of the Na content was observed from the upstream of the station S1 to the downstream of the station S10. As a result, this gradient may be explained by its increase by the tidal effect.

5-2-2 Chloride (Cl^-)

Chlorides exist in all waters at widely varying concentrations, the origin of which may be percolation through saline grounds, infiltration of marine waters into ground or deep water, human waste (urine), mining [20]. In France, recent studies (21) have shown that the source waters often have concentrations of negatively correlated chlorides With altitude. This has been explained by the evapotranspiration / rainfall ratio, lower in altitude, or by a change in the composition of the rains and by an increasing solubilization along the course of the water of the soluble rocks. The spatiotemporal evolution of the chloride content at the estuary level reveals very significant differences between the various sampling points in Figure 9.

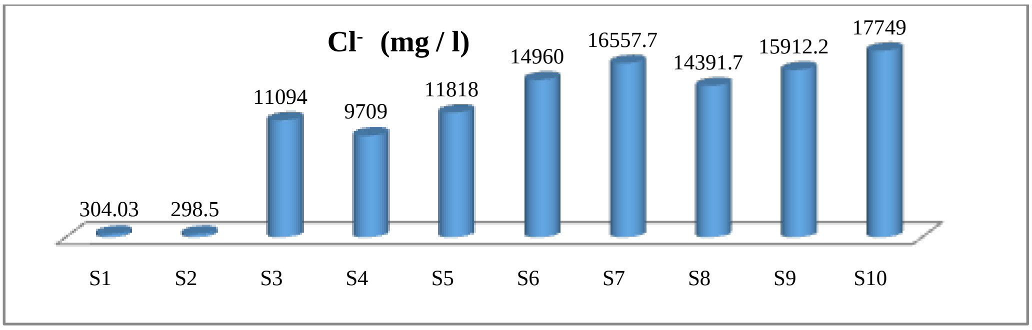

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Fig 9**:** Spatial evolution of mean chloride ion contents in mg / l

The values vary between 0.304 and 0.298 g / l successively in the stations S1 and S2. On the other hand, the highest concentrations are observed mainly at the level of the downstream stations subjected directly to marine influences with values up to 17,749 g / L of salinity in station S10 and 16.557 g / l in station S7. This increase is related to the richness of the chloride waters following the rise of marine waters and the discharges of urban wastewater. The salinity concentrations found in our study are low compared to those obtained in previous studies, where they range from 30 to 40 g / l [16]. Thus, in all the studied stations, the detected values are higher than those of the standards Of the SMO (0.2 g / l), and still exceed 0. 350 g / L considered as the limit value of the chloride contents recommended by the Moroccan standards of water intended for irrigation (fig 9).

6-2-2 Nitrates

Nitrates are the final stage of oxidation of nitrogen. Their presence in water attests to a good recovery in case of organic pollution. Human activity is indubitable as soon as concentrations above 12 mg / l are observed (22). According to Moroccan standards for the quality of human drinking water is 50 mg / l. Nitrate inputs come mainly from the drainage of waters in the catchment, lateral inputs from crops (nitrogen fertilizers). NO_3 can also come from domestic and sometimes industrial wastewater. Nitrates are present at all intake points with levels varying between a minimum value of 0.4mg / l and a maximum value of 3.12 mg / l. The spatial variations of the average contents are very clear with a weakening in the three stations S8, S9 and S 10 fig (10). Indeed, the weakening was explained by the presence of the phytoplanktons. Moreover, a contradictory state was observed in the lower lokoss estuary, the authors found an enrichment in nitrate at the stations located near the mouth. This enrichment, according to the same authors, is due to a very active nitrification during re-oxygenation of the medium. On the other hand, other authors have found that NO3 can reach higher values (24 mg / l), suggesting the presence of organic matter (23). Gassama and Violette (24) explained the increase in NO_3 by the presence of nitrogen fertilizers. However, variations in concentrations at the rest of the stations are very small and insignificant.

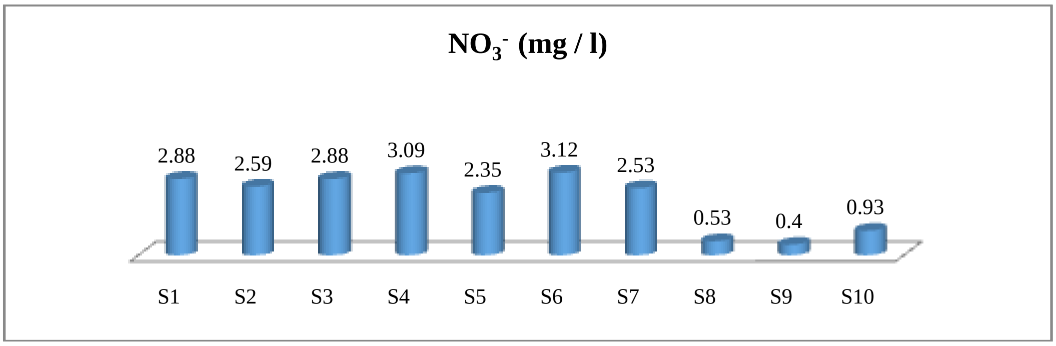

Fig 10: Spatial evolution of the mean contents of nitrite ions in mg / l

Moreover, the values found in nitrates recorded in all the stations remain far below the value allowed by Moroccan standards (50mg / l). As a result, the waters studied are not subject to a pollution risk.

7-2-2 Nitrites (NO_2^-)

Nitrites usually constitute an intermediate stage, not very stable, between ammonium (NH_4^+) and nitrate ($NO3^{-}$) ions. They are found only when there is an imbalance in the oxygenation and activity of the bacterial flora of the ecosystem. Apart from any external input (industrial, chemical, ...), the nitrites come either from an incomplete oxidation of ammonia or, in exceptional situations, a reduction of nitrates under the influence of a denitrifying action. According to figure11, the mean nitrite contents are variable, this variation is significant between the stations, which can be explained by the geographical location of each site analyzed. For stations S1 to S5 the average nitrite content does not exceed the value 0.09mg / l, this value remains below the limit set by the WHO (0.1mg / l). As a result, Is attributed on the one hand to the speed of the reactions of the transformation of ammoniacal nitrogen into nitrite and nitrate and on the other hand by the absence of sources of urban and industrial pollution.

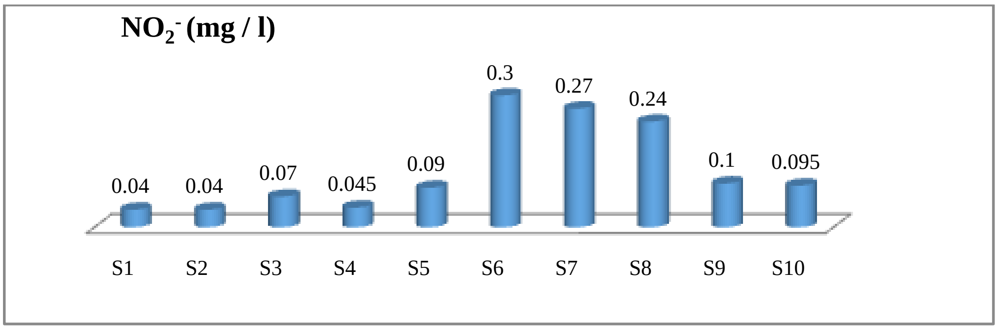

Fig 11: Spatial evolution of the mean contents of nitrate ions in mg / l

In addition, the stations S6, S7, S8 and S9 have higher contents greater than 0.1mg / l (fig 11). These high levels of nitrite would be linked to the drainage waters of agricultural land in the catchment area, wastewater from urban areas and effluent from the Unimer industrial unit.

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8-2-2-Ortho-phosphates (PO_4)

Ortho-phosphates usually have an urban origin (detergent components) or an agricultural (leach fertilizer), they are like nitrates, a major nutrient in plants, which can lead to their proliferation in aquatic environments from Of 0.2mg / l. It is generally considered that variations in phosphate concentrations are the limiting element of eutrophication phenomena (25). Fig (12), shows that mean values oscillate between 0.02mg / l recorded at station S4 and 4.68mg / l detected at station S8. The mean levels recorded in all stations are less than 0.5mg / l except station S8 (4.68mg / l). However, the waters of these stations being in a good class.

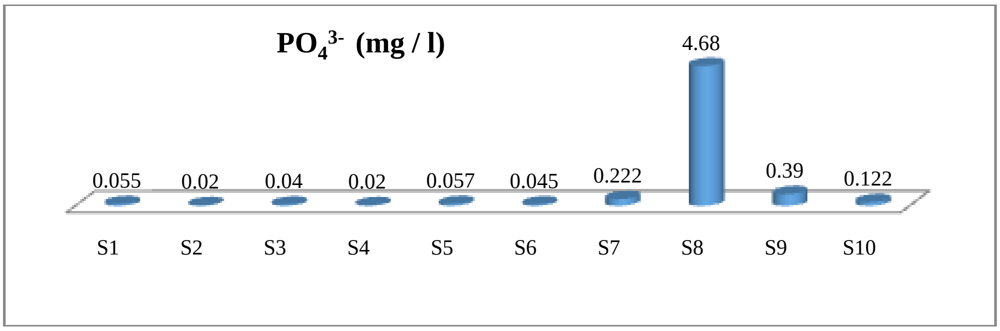

Fig 12: Spatial evolution of mean contents of ortho-phosphate ions in mg / l

Near the collector C3 a significant increase in the ortho-phosphate content was detected at the station S8, this increase in concentration is attributed in particular to the multiplication of urban waste. Consequently, the ecological consequences of these nutrient overloads under very specific hydro-climatic conditions are the processes of eutrophication which are manifested by a plethoric algal production followed often by a fall of dissolved oxygen detrimental to the fauna (26). The temporal variations between the different seasons for each station show no significant deferences.

9 -2-2 Sulfates

The natural origins of sulphates are rainwater and the solution of evaporite sedimentary rocks, notably gypsum (CaSO4), but also pyrite (FeS) and, more rarely, magmatic rocks (galena, blende, pyrite. Anthropogenic origins are the burning of coal and oil, which results in significant sulphide production and the use of chemical fertilizers and laundry (27). The reversible transformation of sulphates into sulphides occurs through the sulfur cycle (28). Surface waters contain widely varying sulphate contents and generally range from 2.2 mg / L to 58 mg / L [29]. The mean values of this parameter in the studied waters are very variable and oscillate from station 1 to station 10 between 97.66 mg / L and 1693.4 mg / L (fig.13).

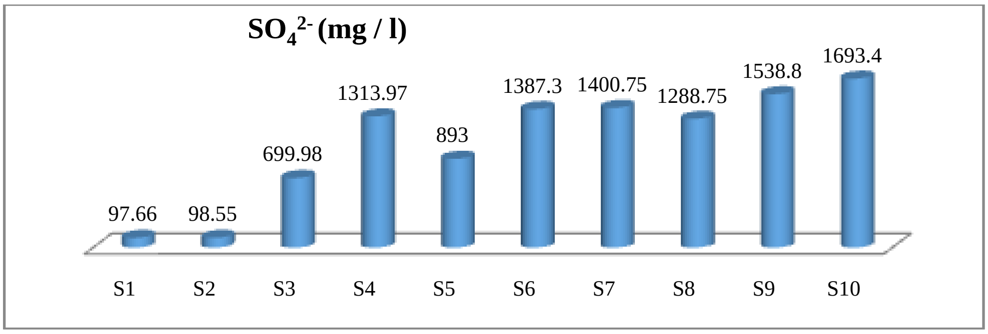

Fig13: Spatial evolution of mean sulfate ion contents in mg / l

This increase in sulphate levels due to the space factor in the study area may be due to domestic releases from collectors C1, C2 and C3, and the cultivation and industrial fields at the edge of the estuary. According to the draft Moroccan water quality standards for irrigation which require a limit value of 250mg / l of sulphate, the majority of the waters of the prospecting sites have a very high content do not correspond to this value, except the waters Of stations 1 and 2, stations 1 and 2 are far from any anthropic domestic and industrial input. Thus the enrichment of sulphate at the levels of s1 and s2 could be due to agricultural activity [30].

III. Conclusion

The surface water quality of the Oued oum Er -Rabia estuary depends on the lithology drained by this watercourse as well as the non-negligible influence of the agricultural activity located on the banks of this watercourse Without forgetting the contributions of domestic, industrial origin poured by the collectors.The results of the physicochemical analysis presented in this work showed that the pH is close to neutrality. The low mineralization at the stations S1 and S2 due to the low conductivity with an average of µS / cm.the significant values of conductivities recorded at the other sites show a strong mineralization, this is due mainly to the dominant marine influence At the estuary level. Thus the values and found of the calcium and magnesium hardness are variable and present a certain heterogeneity between the stations, they are important at the level of the stations contaminated by the urban and industrial discharges, which means that the waters of the latter which are unfavorable to the environment, Irrigation and lower upstream of the estuary (station S1 and station S2). The variations of the chloride and sodium contents are similar to those of the conductivity. These two chemical elements represent the major ions of the mineralization so this water has a sodium chloride facies.Since nitrates are toxic to the human body, presence in large quantities degrades the quality of the water and are indicators of pollution. It is noted that the mean nitrate content varied during the study cycles from 0.022 to 0.41 mg / l, the normal nitrate level was set at 50 mg / l according to the WHO and that the variation between the different points of Levies is low. Therefore, this descriptive parameter of water quality is unlikely to disturb aquatic life in the waters of the Oum Er-Rabia estuary.The sulphate ions remain generally linked to the hydrological sequences of the rivers (flood and low water) [28] and to the nature of the discharge load and show a large difference between the minimum values 97.66 and 98.55mg / l measured at stations S1 and S2 and the maximum values 1693.4mg / l recorded in station S10.This could be related to very important seasonal variations. Spatial variation shows an evolution marked by a gradual increase in discharges into the receiving environment rich in sulphates upstream downstream and contributions of geochemical origin, the erosion of which is the main contributing cause of dissolution Gypsum and sulphides present in sedimentary rocks. According to all who said, the waters of the estuary are in a critical state whose pollution persists. However, this study revealed two types of influences:

-Anthropogenic influence brought about by domestic, industrial and agricultural wastewater is combined with an oceanic influence quite downstream where the importance of the flow and the ocean mass that penetrates into the estuary, Aided by the low slope of the main stream, leads to an increase in chlorides, sulphates, calcium, etc. This influence makes it possible to define a gradient of mineralization decreasing from the mouth (S5) towards the interior.

-An upstream terrestrial influence, where the saliferous and gypsiferous geological nature that mainly characterizes the upstream stations (S1 and S2) are the origin.

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