Characterizing the Physical and Chemical Properties of Wastewater in the City of Missour, Morocco

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Abstract

These contaminated and polluted waters are reused directly in the irrigation of parcels with high agricultural activities downstream of the city. They have a negative impact on the environment and can cause illness for both consumers and farm workers. The resolution of this problem requires the establishment of a sewage treatment plant for their reuse without danger in agriculture.

The objective of our work is to determine the degree of pollution of wastewater from Missour, based on results obtained by physicochemical analyzes of samples taken from collectors of the city during the period spread between the months of November 2014 and October 2015.

The temperature varies between 13 ° C and 26,7 ° C, the pH is about neutral from 7,01 to 7.84. The electrical conductivity from 1963 to 5590 µS/cm, salinity from 1.1 to 3 mg / l, turbidity from 42,1 to 1125NTU, COD Moy = 2066,1 mg / l, BOD_5 Moy = 1063,7 mg / l and the TSS Moy = 1739,1 mg / l. Although these waste waters have a high organic load DBO_5 / COD = 0,51 ; TSS / BOD_5 = 1,63, they have a satisfactory biodegradability.

Examination of COD / BOD_5 = 1,94 clearly emphasizes the biodegradability of these waters for which biological treatment seems quite suitable. However, account must be taken of domestic wastewater mixed with effluent from the municipal slaughterhouse and effluent from the regional hospital.

The values obtained are above the wastewater discharge standards recommended by WHO. At the end of this research, it turned out that wastewater from the city of Missour is of bad quality to very bad.

Introduction

Demographic, economic and urban increases are at the root of various sources of environmental pollution, especially in developing countries that are less concerned and less aware of health risks. Among these sources of pollution, the production of wastewater that is often released into the natural environment without prior treatment. This pollution generates many waterborne diseases that can be the cause of certain epidemics.

Urbanization, rapid economic development and prosperous activities have an adverse impact on the surrounding environment and mainly on aquatic ecosystems whose watercourses are an integral part. The discharge rate of raw sewage is intensifying with extremely rapid speed, thus constituting an important source of pollution [12] and the consequences are hellish on the quality of the rivers [16].

In developing countries, the problem is seriously posed [14] due to the scarcity of treatment plants. The impact of pollution on safety and human health and wildlife depends on the physical and chemical characteristics of pollutants and exposure to such polluted water systems [13]. As a result, assessment and monitoring of water quality has become of paramount importance [15].

The city of Missour is no exception to this rule. Indeed, this city among the cities of Morocco in full urban expansion with an estimated daily volume of wastewater discharges of 880 m3 / d in 2012. These discharges will reach 940 m3 / d in the year 2020 [2]. This can be explained by the increase in the urban population, the increase in the supply and the individual consumption of drinking water as well as the significant use of water by the industrial sector. Hence the need for the realization of a treatment plant.

The present work aims to determine, through the results obtained, analyzes of the different physicochemical parameters, the levels of sewage pollution in the city of Missour.

Materials and method

The city of Missour is located 205 km from Fez and 175 km southwest of the city of Guércif on the RN 15 connecting these two cities. The presence of the Middle Atlas chain in its northwestern limit, the high atlases to the south and the remoteness of the Mediterranean mitigate the creative marine influences of the rains and give the region a semi-arid climate with long periods of drought this has a direct impact on the water plan of the region.

The city of Missour is part of the watershed of Moulouya which is the main river of the geographic region of North Eastern Morocco. It extends over an area of 18 Km^2. The average altitude is about 890 m (Figure 1).

The wastewater sampling was carried out monthly, from November 2014 to October 2015 from two effluent collectors located near Hotel EL BAROUDI, and a second after the first 500m (Figure 1), Samples of wastewater intended for physico-chemical analysis, have been retained in accordance with the general guide for the conservation and handling of samples according to ISO 5667/3 [3], and Guide of good practice [4].

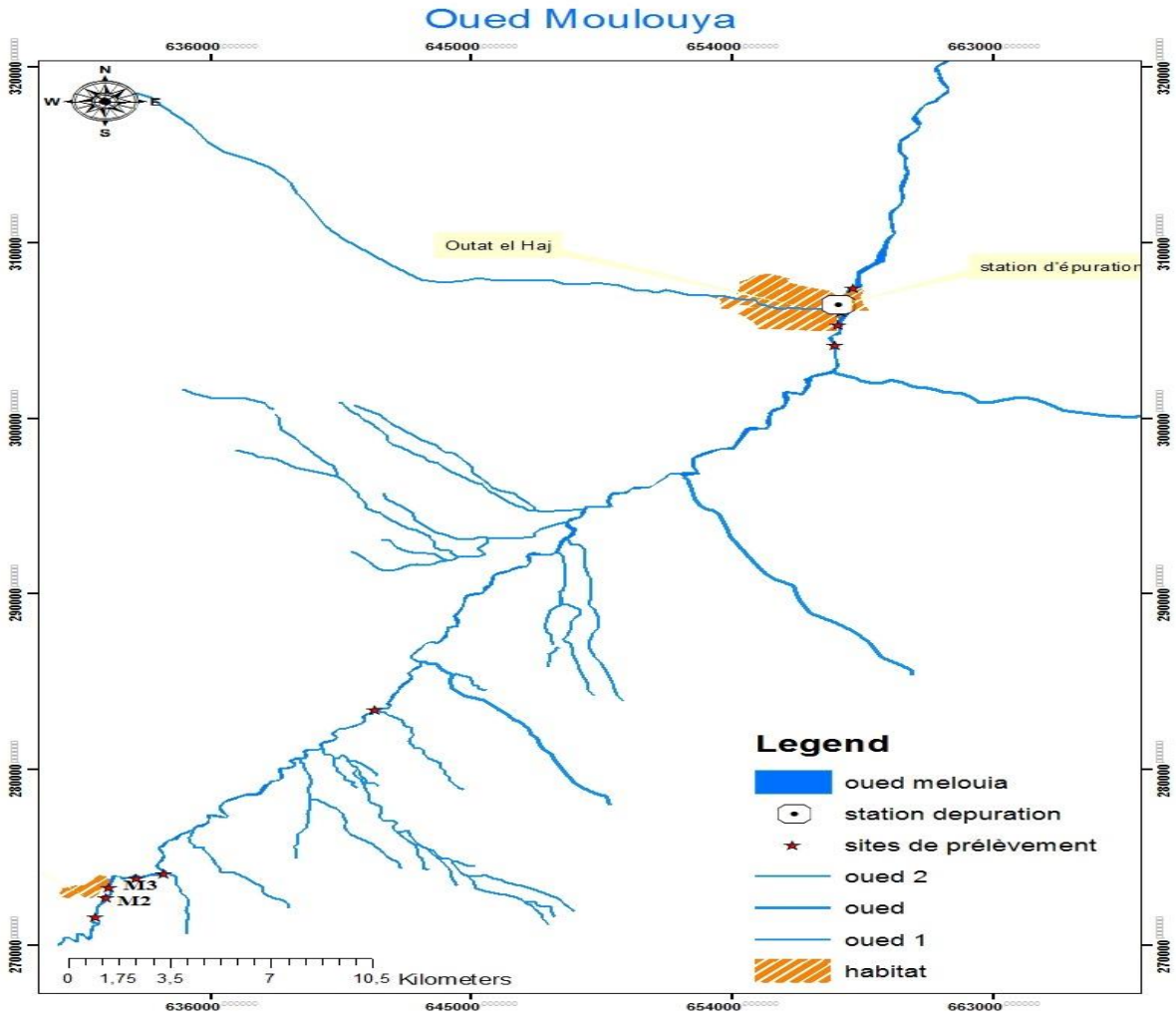

Figure 1: Location of the study area and sampling sites

S ng site to the laboratory. It is always better to take measurements on site. "In situ" measurements of temperature, pH, electrical conductivity, dissolved oxygen and turbidity were performed using a mercury thermometer, a PH-2006 pH meter, a WTW conductivity meter (cond 315i), an EUTCH oximeter, respectively. (cyberscan DO300) and a turbidimeter HACH 2100N.

The measures of all physical-chemical parameters are made within 48 hours of the levies, with standardized methods usually adopted for this type of analysis [5]. The type of method, the apparatus used as well as the reference of the method are summarized in Table 1.

Table 1. Physico chemical Parameters and the reference of the Method of analysis

Paramètre	Unité	Référence	Méthodes
TSS	mg/l	AFNOR, 1999	Filtration Weighing
HCO_3^-	mg/l	Rodier, 2009	Volumetric dosing with HCl (0.1N)
Chlorides	mg/l	Rodier, 2009	Volumetric Method Mohr
Nitrates	mg/l	Rodier, 2009	Method to Salicylates Sodium
Nitrites	mg/l	AFNOR, 1999	Method to Reagent Zambelli
Orthophosphate	mg/l	AFNOR, 1999	Method Ammonium Molybdate
COD	mg d'O_2/l	AFNOR, 1999	Oxidation with potassium dichromate
BOD_5	mg d'O_2/l	AFNOR, 1999	MethodOxiTop

Resultants and Discussion

paramètres	Sites	Min	Max	Moy
Température	M2	13,3	26,7	20,75
	M3	13	26,6	21,01
pH	M2	7,01	7,84	7,25
	M3	7,02	7,77	7,27
CE	M2	1963	3240	2761,08
	M3	1971	5590	3452,58
Salinity	M2	1,1	1,7	1,37
	M3	1,1	3	1,64
Turbidity	M2	42,1	1125	482,7
	M3	44,3	739	347,31
O_2	M2	0,07	0,76	0,30
	M3	0,01	0,71	0,26
HCO_3^-	M2	403,82	774,7	594,32
	M3	425,78	724,68	576,82
Cl^-	M2	355	582,2	441,6
	M3	333,7	979,8	484,22
TSS	M2	232	7632	1951,67
	M3	106	2648	1526,58
BOD_5	M2	700	2150	1115,83
	M3	350	2100	1011,67
COD	M2	1320	4485	2148,67
	M3	696	4200	1983,67

NO_3^-	M2	1,846	53,34	26,78
	M3	1,052	99,6	34,92
PO_4^{3-}	M2	0,61	5,64	3,90
	M3	0,57	5,92	4,11
OM	M2	930	2928,33	1460,11
	M3	465,33	2800	1335,66
NO_2^-	M2	0,21	1,17	0,77
	M3	0,23	1,12	0,73
SO_4^{2-}	M2	122,9	284,4	284,43
	M3	127,1	295,1	295,12
TH	M2	528,8	870,4	870,4
	M3	457,6	976,7	976,74

The raw sewage temperature of the city of Missour is between 13 ° C and 26,7 ° C with an average of 20,8 ° C. Water temperatures are closely dependent on the air temperature. Since the samples were collected at the same time of the day, corresponding to the maximum period of sunshine, the temperature differences were not very extensive. The recorded wastewater temperature values are below 30 ° C considered as the limit value for direct discharge into the receiving environment [28]. Similarly, these values are below 35 ° C, considered as an indicative (indicator) limit value for water intended for irrigation of Morocco [7].

These recorded temperatures are included in the range of the direct discharge limit values in the receiving environment [6].

The pH values of the raw sewage measured oscillate between 7,01 and 7,84. The pH of the wastewater from our work tends towards neutrality and still remain close to each other and are in the range of Morocco standards of water quality for irrigation [7], and in the range of direct discharge limits is between 6,5 and 8,5 [6].

The pH, indicates the alkalinity of wastewater, its role is crucial for the growth of microorganisms which generally have an optimum pH ranging from 6,5 to 7,5. This factor is considered as an indicator of several biochemical activities, including photosynthesis and the biodegradation of organic matter [17]. The pH of wastewater in the city of Missour is close to neutrality, with sometimes a slight tendency towards alkalization. This is attributed to the amount of groundwater (used for the production of drinking water) in bicarbonate ion [20], and the variation in temperature.

These values of conductivity are a little high, this could be explained by the rejection of wastewater from small industrial units rich in fertilizers, and on the other hand the rejection of highly mineralized municipal slaughterhouse waste connected to the sewerage network, but this average conductivity remains close to the direct discharge limit values [6], and higher than the maximum value 3000 µs / cm of water intended for irrigation [7].

The Electrical conductivity is probably one of the simplest and most important for quality control of wastewater. It reflects the degree of global mineralization, it tells us about the salinity rate. The conductivity values recorded for the raw wastewater of the city of Missour vary between 1963 µS / cm and 5590 µS / cm. With an average of 3106,8 µs / cm.

In general, salinity follows the same trends as electrical conductivity. The results obtained show that the values oscillate between 1,1 mg / l and 3 mg / l.

The turbidity values vary between 42,1 NTU and 1125 NTU, which allows us to conclude that wastewater from the city of Missour exceeds the Moroccan emission standards which are between 5 and 30 (discharge standards) ie. d. that these waste waters are highly turbid.

The average value of salinity is 1,5 mg / l. The comparison of these values with the standard rejection grid makes it possible to say that the raw wastewater of the city of Missour is of poor quality.

The concentration of dissolved oxygen varies between 0,01 and 0,76 mg / l. The lowest values of the dissolved oxygen concentration, which is reflected by the high organic load in the raw wastewater, and the presence of a bacterial activity consuming the dissolved oxygen and the decrease of the self-cleaning capacity of these waters, with an average value does not exceed 1,71 mg / l, which makes the wastewater of the city of Missour under saturated oxygen which accentuates the anaerobic fermentation and the release of bad odors....

The suspended solids represent all the mineral and organic particles contained in the wastewater. Knowledge of the concentration of colloidal elements in wastewater is necessary in the evaluation of the impact of pollution on the aquatic environment. The amount of suspended matter varies between 106 mg / l and 7632 mg / l, with an average of 1739,1 mg / l.

The results obtained show that the values vary in the studied releases between a maximum of 774,7 mg / l and a minimum of 403,8 mg / l. The average of the two releases is 274,2 mg / l.

The highest levels of measured TSS are attributed to the month of March. This could be explained by a minimal consumption of water in this period of cold in the homes, which results in the discharge, in the sewers, of concentrated waste water, loaded in TSS. The values found in TSS are very high at 50 mg / l considered as wastewater standards for direct discharges [7]

The recorded values of BOD_5 and COD are respectively between 350 mg / l of O_2 and 2150 mg / l of O_2, and between 696 mg of O_2 / l and 4485 mg of O_2 / l, with average values of 1063,7 mg / l of O_2, and 2066,1 mg / l of O_2

The high BOD_5 values could be explained by the abundance of organic matter, so 90% of the BOD_5 values are above the usual Moroccan urban wastewater (MUW) ranges and 10% are included in the same ranges [17], [18] recorded for the companions of June (Figure 10). The average value of BOD_5 is greater than 100 mg of O_2 / l considered as the limit value for direct discharges [7]. This wastewater is classified as very poor, according to the quality standards of surface water [7].
COD allows the concentration of organic or inorganic matter, dissolved or suspended in water, to be assessed through the quantity of oxygen required for their total chemical oxidation (Rodier, 2009). The average COD value of raw wastewater in the city of Missour is greater than 500 mg / l considered as the limit value for direct discharges [7]. Moreover, this wastewater is of very poor quality (> 80mg / l) according to the quality standards of surface water [7].

The average value of the COD / BOD_5 ratio is 1,94 corresponding to that of the wastewater with a ratio DCO / BOD_5 of less than 3 [7]. Therefore, it can be concluded that even though urban wastewater has a high organic load, it is easily biodegradable. The review of this report highlights the biodegradability of wastewater mixed with municipal slaughterhouse discharges and discharges from the city's regional hospital to which biological treatment seems quite appropriate. These results are consistent with those reported by [8] and [9].

To characterize an industrial pollution, one often considers the ratio BOD_5 / COD, which gives very interesting indications on the origin of a pollution of the waste waters and its possibilities of treatment. For our study, this ratio is relatively average of the order of 0,51. This is the general case for discharges loaded with organic matter. This organic load makes these wastewater fairly unstable, that is to say they will evolve quickly to (into) forms "digested" with the risk of release of odors. Indeed, this type of wastewater is predominantly organic.

For raw wastewater from the city of Missour, the average ratio of BOD_5 / COD is of the order of (0.51), which confirms that this wastewater is heavily loaded with organic matter. This result obtained is confirmed by the estimate of the oxidizable material, which is of the order of 1397,9 mg / l with a mean ratio of MES / BOD_5 of 1,63. On the other hand, the average ratio of COD / BOD_5 is low (1.94), which allows us to deduce that the organic matter load in the city's wastewater is easily biodegradable according to Henze et al. [10].

The concentrations of chloride ions measured in the two collectors ranged between 979,8 mg / l, in the month June at the level of the collector C2 and 333,7 mg / l in the month December at the level of the collector C1.

The low levels of phosphates in Figuig wastewater are due to the low use of laundry products in the homes. The laundry is usually done at the level of washing outside the homes, these waters do not open sanitation networks.
The physicochemical parameters of wastewater in the city of Missour exceed the general limit values for direct and indirect discharges into the receiving environment [7].

The assessment of the degree of organic pollution locates the wastewater of the city in the average concentration range to be raised.

Wastewater from the city of Missour generates a significant pollutant load by spilling on the receiving environments such as Oued Moulouya, and especially during its stagnation can create a favorable environment for the proliferation of mosquitoes vectors of waterborne diseases, hence the need for setting up a wastewater treatment plant for proper treatment in order to render the wastewater harmless for the receiving environment and for later reuse in irrigation. At the end of the assessment of the degree of organic pollution, it can be seen that all the parameters studied (in particular with BOD_5, COD and TSS) locate the wastewater analyzed in the medium-concentration slice to be raised [11].

Examination of the COD / BOD_5 ratio highlights the biodegradability of wastewater in the city of Missour. It can be concluded that this wastewater is readily biodegradable to which biological treatment seems quite suitable.

The treatment of this wastewater is necessary to produce an effluent that meets the standards of direct and indirect discharges according to the Ministry of the Environment of Morocco (2002). The City of Missour generates waste water that is suitable for biological treatment in terms of COD, BOD_5, and TSS. However, the physicochemical and microbiological characteristics of domestic wastewater mixed with effluent from the slaughterhouse and the wastewater must be taken into account regional hospital.

The following figures and table show the interpretation elements of the analysis (own values, the contributions of the parameters to the constitution of the principal components and matrix of the correlations): Table 3 allows a first topological approach of the various variables (16) and their grouping [19] on the first three principal components from their contributions. The first three factors account for nearly 65.09% of total inertia (Figure 3). The first axis F1 (25.81% of inertia) mainly consists of a strong correlation with the parameters related to the organic load of water (COD, BOD_5, alkalinity and suspended matter). Many parameters related to the mineralization (chlorides, salinity, sulphates and total hardness) shows strong correlations with the second axis F3 (15.92% of inertia) (figure 3). The second axis F2 (23.36% of inertia) is positively correlated with temperature, dissolved oxygen, nitrites and orthophosphates, negatively correlated with the hydrogen potential (Figure 3).

The Circles of correlations, which represent the projection of the coordinates of the variables in the plan of the first three components taken two to two (Figure 3). This typology of the variables is accompanied by a typology of surveys that explains the phenomena, 65.09% of the information being held by the first three factors, only the representations in the plan F1 x F2 and F1× F3 were realized (Figure 3).

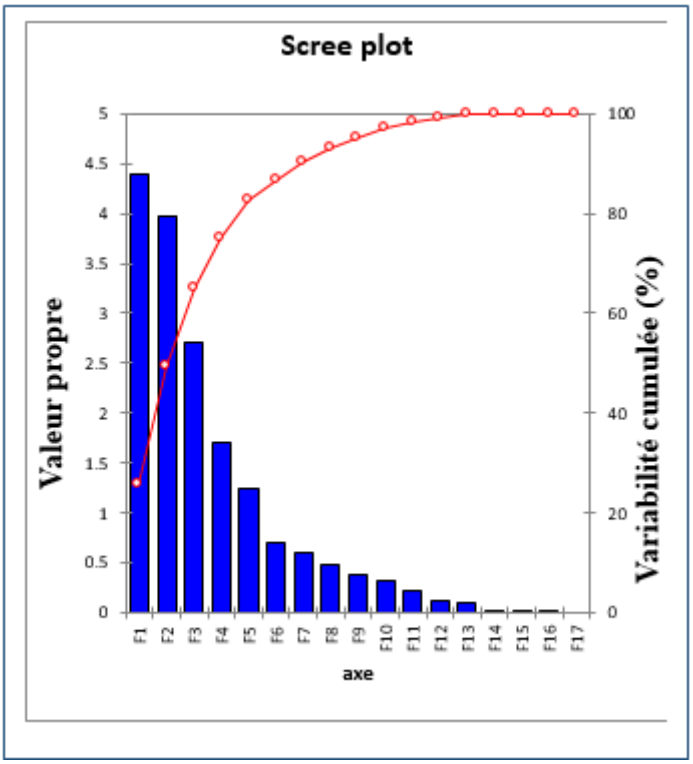

Figure 2 : graphe des valeurs propres

Table 3 : contributions of the parameters to the constitution of the principal components

	F1	F2	F3
T	-0,267	0,762	-0,293
pH	-0,027	-0,726	-0,075
CE	-0,476	0,442	0,466
Salté	-0,244	-0,127	0,879
NTU	0,125	-0,274	-0,170
O2	0,475	0,722	-0,096
HCO3-	0,562	0,411	0,131
Cl-	-0,125	0,124	0,884
MES	0,755	0,198	0,065
DBO5	0,960	-0,077	0,142
DCO	0,964	0,107	0,151
NO3-	0,092	-0,075	0,058
PO43-	-0,104	0,651	-0,091
MO	0,974	0,017	0,148
NO2-	-0,107	0,862	-0,226
SO42-	0,169	-0,580	0,382
TH	-0,166	0,551	0,714

Based on the maps factorials F1 × F2 and F1 × F3 (Figure 4), the results of the ACP show that the more share of different months are positioned (on F1) depending on the degree of pollution of their waters. Thus, the months of study, the more polluted (March, April, November and December) are located on the negative side of F1, then that the months (June, July, September and October) the least polluted by report to the other lie on the positive side.

Then, the projection of the individuals in the factorial plan F1 and F2 have helped distinguish 3 different groups (Figure 4):

- group 1: it contains only the months of march, which has water of very poor physical-chemical quality, characterized by a high concentration of organic matter and nutrients and phosphates.
- group 2: brings together the months of January, February, April, November and December, which also have high levels of organic pollution indicator germ,
- group 3: which have less polluted waters in parameters indicating organic pollution and in high dissolved oxygen concentration compared to the first month of groups 1 and 2.

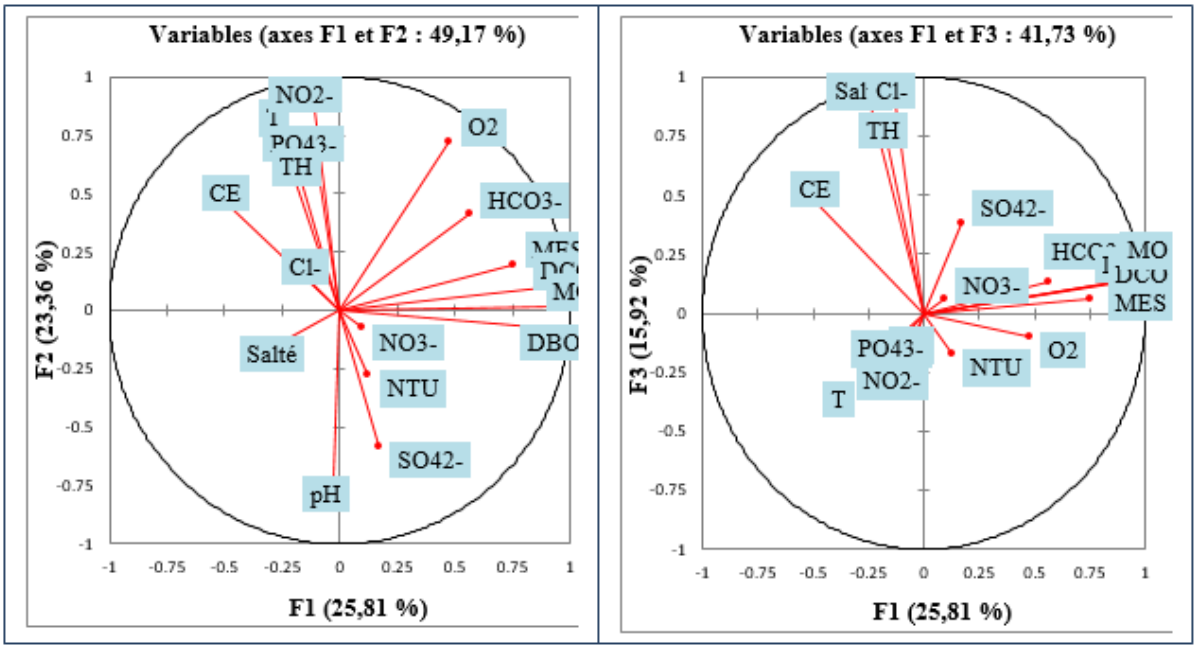

Figure 3: correlations circle of variable physicochemical F1×F2 and F1× F3

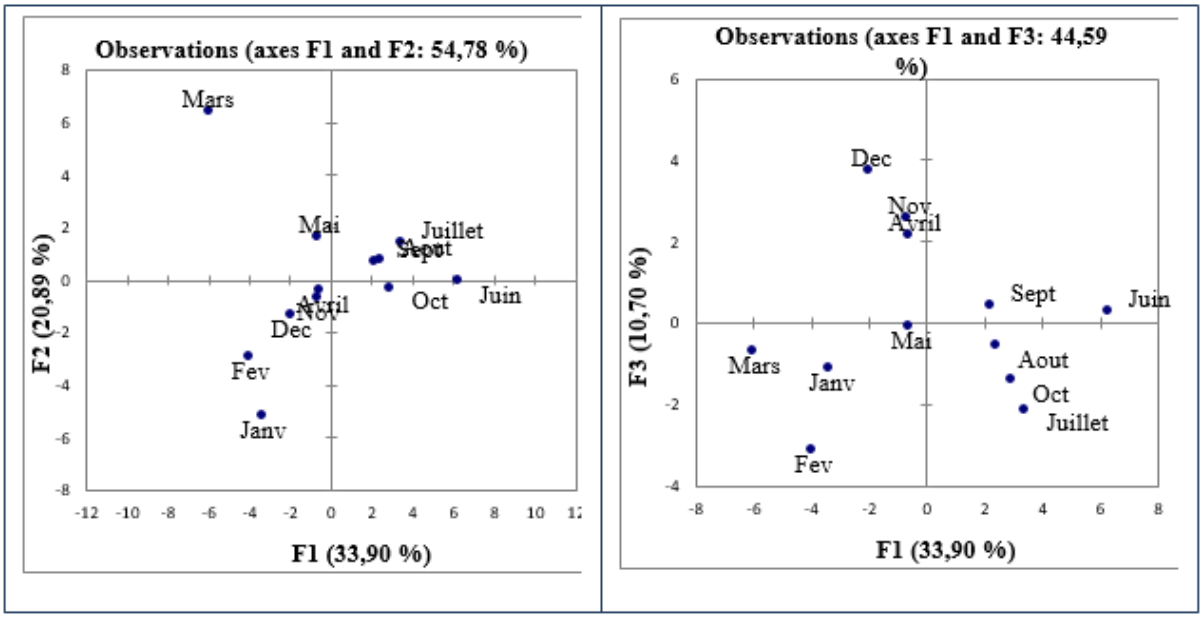

Figure 4 : Projected stations on the factorial plane F1 × F2 and F1×F3

An ascending hierarchical classification (AHC) has been performed on the physical-chemical data in order to complete the results of the PCA.

The criterion used for CAH is that of maximizing the ratio of inter-group variance to intra-group variance. The selection of an optimal number of partitions is done by the joint use of CAH and dynamic clouds [18].

In our investigation the classification was carried out on the average values of the months calculated from the date of the different sampling stations (figure 5)

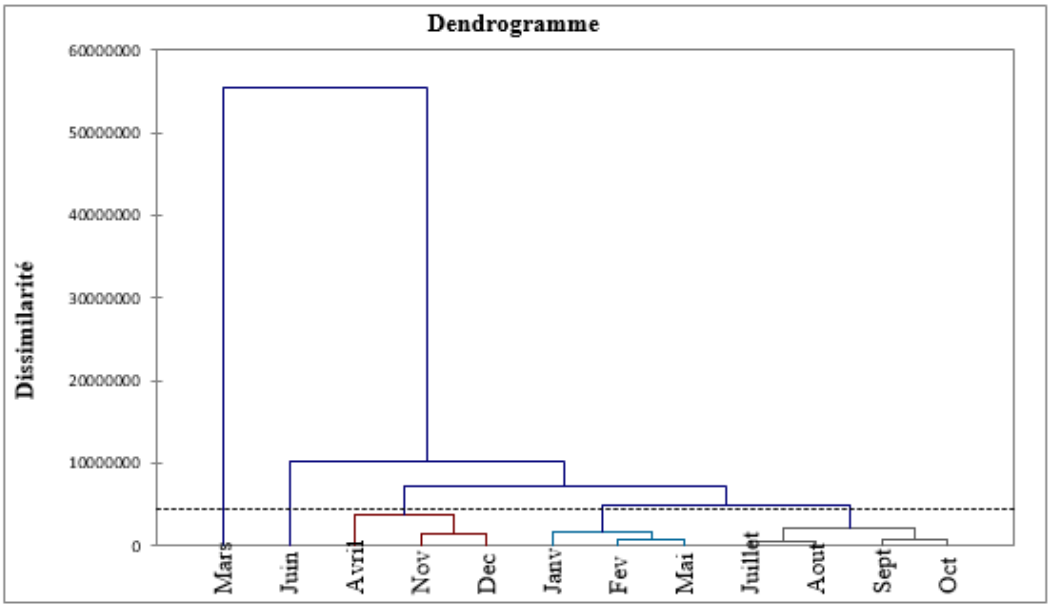

Figure 5: résultats de la classification ascendante hiérarchique des 12 mois de prélèvement

This analysis allowed to distinguish 5 groups of months, according to the anthropic influences to which they are subjected:

- ✓ The months (April, November and December) from the first C1 group with little mineralization, all these stations having a high concentration of Nitrates and orthophosphates and low content of TSS.
- ✓ The second group (January, February and May) undergoing organic pollution characterized by intermediate detectors in nitrates, sulphates.
- ✓ The months (March). This station has high concentrations of organic matter and high levels of TSS, bicarbonates and chlorides and low dissolved oxygen content.
- ✓ The fourth group (June). This station is characterized by relatively high concentrations of dissolved oxygen and low values of BOD_5, COD, NO_3^- and PO_4^{3-}.
- ✓ The last group (July, August, September and October)

Conclusion

The analysis of the physical-chemical indicators of pollution of the two domestic releases M2 and M3 of the city of Missour has allowed us to conclude:

The domestic waters of the city of Missour have a temperature and a pH lower than the standards of the standard committee of Morocco (CNS, 2013)

The values of conductivity, salinity, dissolved oxygen and dissolved potential are discharges of poor to very poor quality.
Total Suspended solids, BOD_5, COD releases far exceed the limit concentration of direct discharge according to (CNS, 2013)

Nitrates from the Missour town discharge are above water quality standards for irrigation. The raw wastewater from the city of Missour is predominantly organic and is easily biodegradable as it is of domestic origin.

These results show that Missour's domestic wastewater is highly polluted since the majority of the analyzes revealed levels that exceed the values recommended by Moroccan standards, which confirms the contamination

of Oued Moulouya. However, their direct use for irrigation could seriously affect the receiving environment and generate at the soil level the phenomenon of physical-chemical or biological clogging due mainly to the presence of SS and the precipitation of salts. Following the direct discharge of water from the sites, could have an effect on the entire aquatic ecosystem and the environment..

References

[1] Chaouki HAMID, Lahcen ELWATIK, Youssef RAMCHOUN, Rachid FATH-ALLAH, Abdelrhafour AYYACH, Zhor FATHALLAH, Azzeddine EL MIDAOUI, El Mahdi HBAIZ, «*Etude des performances épuratoire de la technique du lagunage aéré de la station d'épuration de la ville d'Errachidia - Maroc-* », 2111-(2014) 4706,

[2] ONEP «*Rapport annuel d'exploitation du service assainissement liquide*», Rabat, 2012

[3] ISO 5667/3, *Qualité de l'eau - échantillonnage - Guide pour la conservation et la Manipulation des échantillons*, 1994.

[4] ONEP, *Caractérisation quantitative et qualitative des eaux usées, Guide de bonne Pratique, Direction Laboratoire de la Qualité des Eaux*, ONEP, Rabat, 1999.

[5] RODIER J. *L'analyse de l'eau naturelle, eaux résiduaires, eau de mer, 9 Edition Dunod, Paris*, 1579p. (2009)

[6] VLRDI : Valeurs limites des rejets directs et indirects du Maroc.

[7] Ministère de l'Environnement du Maroc « *Normes marocaines, Bulletin officiel du Maroc* », N° 5062 du 30 ramadan, 1423. Rabat, 2002.

[8] Gnagne T. et Brissaud F. "*Etude des potentialités d'épuration d'effluents d'abattoir par nfiltration sur sable en milieu tropical*, " Sud Sciences &Technologies, n°11, Décembre 2003.

[9] Zerhouni R. A, "*Flore algale des eaux usées de la ville de Fès et étude de la capacité de certaines espèces à éliminer la charge azotée, phosphatée et quelques métaux lourds (Chrome et Cadmium)*, " Thèse de Doctorat, Faculté des Science, Dhar El Mahraz, Fès, Maroc, pp. 146, 2003.

[10] Henze M., Harremoes P., Jansen J. L.C and Avrin E., "*Wastewater treatment*," 2nd Ed, springerverlag, Berlin, 1997.

[11] Metcalf et Eddy, INC..*Wastewater engineering: Treatment, Disposal and Reuse. 3ème Edition Library of Congress Cataloging in publication data*, TD, 645, (1991) T34.

[12] Chau K.W.& Jiang Y.W. (2002). Three-dimentional pollutant transport model for the Pearl River Estuary. Water Res. 36 (8); 2029-2039.

[13] Jonnalagadda S.B &Mhere G. 2001. Water quality of the odzi river in the eastem highlands of zimbabwe. Water Res. 35 (10); 2371-2376.

[14] Jonnalagadda S.B., Mathuthu A.S., Odipo R.W. &Wandiga S.O. (1991).River pollution in developing countries. A case study III: Effect of industrial discharges on quality of Ngong river water in Kenya. Bull. Chem. Soc. Ethiop.5; 49-64.

[15] Ongley E. (1998). Modernization of water quality programs in developing countries: issues of relevancy and cost efficiency. Water Qual. Interant. Sep/Oct.: 37-42.

[16] Pesce S.F. &Wunderlun D.A. (2000).Use of water quality indices to verify the impact of Cordoba city (Argentina) on Suquia River. Water Res. 34 (11); 2915-2926.

[17] Edeline F. (1980): L'épuration biologique des eaux usées résiduaires, théorie et technologie. Edition CEBEDOC,

[18] Celeux G., Diday E., Govaert G., Lechevallier Y., Ralambondrainy H. (1989). Clssification automatique des données, Dunod, Paris., 238p.

[19] Chessel D., Mercier P. (1993). Couplage de triplets statistiques et liaisons espèces environnement. In : Lebreton J. D. & Ausselain B. (eds) Biométrie et Environnement, Paris Masson., 15-44.

[20] TORRENS A., ALCALDE L., SALGOT M., CASANOVA P., QUERALT E., ELHACHEMI O., ELHALOUANI H. & GONZALEZ C., (2010) : Sustainable water resources management in the Oasis of Figuig, Morocco. International IWA conference on sustainable solutions for small water and waste water treatment systems. Girona, Spain