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Iron and Manganese comportment in the dam lake Sidi Mohamed Ben Abdellah in the Bouregreg basin (Morocco)

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Abstract
The study of Fe and Mn, key factors responsible for the deterioration of the water quality in an aquatic environment, has been undertaken to assess the mobility potential of these elements on the surface and bottom in SMBA Dam of Bouregreg basin. Indeed, the concentrations of Fe and Mn recorded during the campaigns of analyzes performed during 2004 (summer) and 2005 (winter) are generally spatial and temporal variables. The mean levels in our study are relatively low in surface and do not exceed the limit values of Fe (0.3 mg/l) and Mn (0.1 mg/l). Moreover, the highest values were found in the bottom sometimes exceeding standards limit and at the same time raising the difficulties of water treatment. The analysis of Iron and Manganese in the dam SMBA and spatial and temporal taking into account the factors that determine their presence, show a double origin is linked to their release from the sediment deoxygenated, is due to the transfer of these two metals runoff catchment Bouregreg to the dam.

Key words- water, iron, manganese, eutrophication, lake, Morocco.

Introduction
Water plays an important role in the Moroccan economy including tap water by humans. However in the last decades, we noticed the deterioration of stream water quality due to industrialization and human activities [1]. Water is a natural resource representing an essential base for the majority part of human activities. However in Morocco, water resources are limited and irregular in time and space [2].

The Bouregreg basin is characterized by a semi-arid Mediterranean climate influenced by climatic and hydrological environment conditions [3, 4]. The Parallel, urban development and the continuing growth of demand for drinking water and industrial of the Rabat-Salé-Zemmour-Zaer region have imposed the use to the construction on the Bouregreg basin of Sidi Mohamed Ben Abdellah (SMBA) dam (**Photo 1**).
It was put into service in 1974. It is intended for the production of drinking water. But, this source of water is facing for pollution caused by undesirable substances; inter alia the presence of Fe and Mn in the waters of the withholding of the dam when their levels exceed standards. Thus, from this finding, several questions are posed on the presence of Fe and Mn in such an environment [5,6].

To answer at this problem, we have shown by the present work the situation of Fe and Mn in the dam Lake in our study during 2004-2005. The purpose of this study through the analysis of the data identified during this period allowed us to deduct.

2. Study site

Versant basin of the Bouregreg has a surface of 9800 Km^2. It's located in the Northwest of Morocco, between latitude 33° and 33° 50' North and longitude 5° 30' and 7° West. It is limited to Northeast by the Sebou basin, to South by Om-Errbia basin, to Southwest by the basins of the coastal rivers (Cherrat, Nefifikh and Mellah) (**Fig. 1**). It opens to the West on the Atlantic Ocean.

Photo 1: SMBA dam (Bouregreg Morocco)

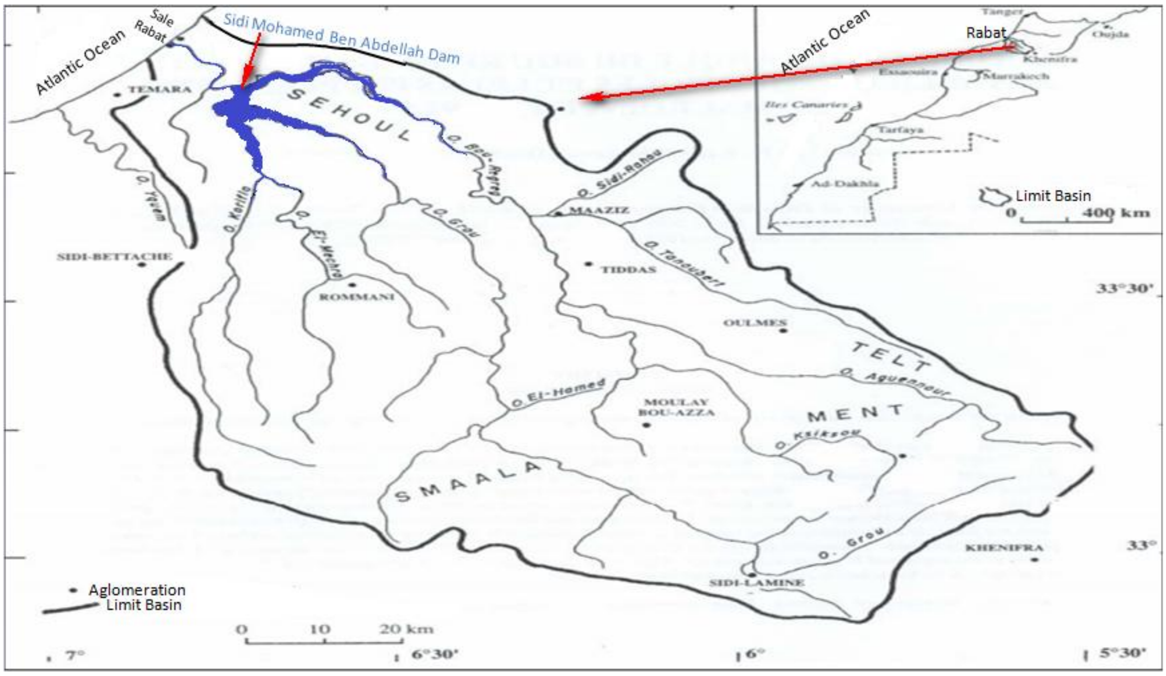

Figure 1: Delimitation the study basin (Bouregreg)

The development of the agglomeration urban occasioned by the increase in the socio-economic needs and lifestyle change have imposed the construction of the Lake dam of SMBA to perpetuate the potable water supply of any Atlantic coast Sale in Casablanca and produce hydroelectric power. In fact, it can actually store a water volume of 1025 Mm^3 and regulate a volume of 340 Mm^3 /year from the furnishings in 2005. However, this dam knows a siltation of the average order of 2.22 Mm^3/year, thermal stratification [7] and eutrophication [8], which often results in favorable conditions for the release of iron and Manganese from the sediments or submerged rocks.

3. Materials and methods

To analyze the raw water of the withholding of the SMBA dam, sampling were taken at the level of intake of the National Office of drinking water just on the surface and at the bottom.

During the two hydrological years 2004 and 2005, sampling of water were collected in polyethylene bottles specially washed with hydrochloric acid (10%) and then rinsed with distilled water. They are then fixed by nitric acid at 2% and transported at low temperature (+4°C) to the national office of drinking water laboratory where the analyses were performed.

The determination of Mn was detected by Spectrophotometry of Atomic Absorption (SAA) with graphite (Varian AA240Z GTA 120) and Fe by SAA with furnace (VARIAN AA 20) (**Photo 2**).

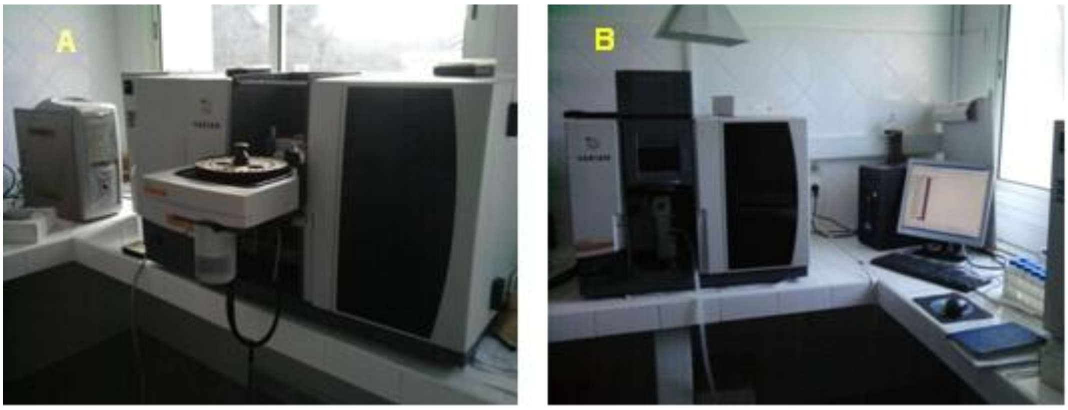

Photo 2: SAA (A: SAA with graphite and B: SAA with furnace)

4. Results and discussions

As a result of erosion and chemical weathering, water inputs were loaded by dissolved particles and suspended mutter during the rainy periods at the level of the Bou Regrg basin [9, 10].

4.1. Average inputs of the water in SMBA dam

The evolution of the hydrological mean inputs of recorded water in the years 2004 and 2005 in our study showed seasonal and irregular inter-annual variation (**Fig. 2**). The minimum of inputs was recorded during the dry year of 2004 and maximum during the year of 2005. The hydrological year 2004 was characterized by drought whose the maximum inputs does not exceed 25 Mm^3. However, the maximum inputs were reached at 279 Mm^3 in the humid period of the year 2005. This irregularity allows for Lake to receive the majority of its annual inputs, in a few months or a few weeks and then a long stability of the water mass. It is a factor favoring the phenomena of siltation and thermal stratification [7, 11].

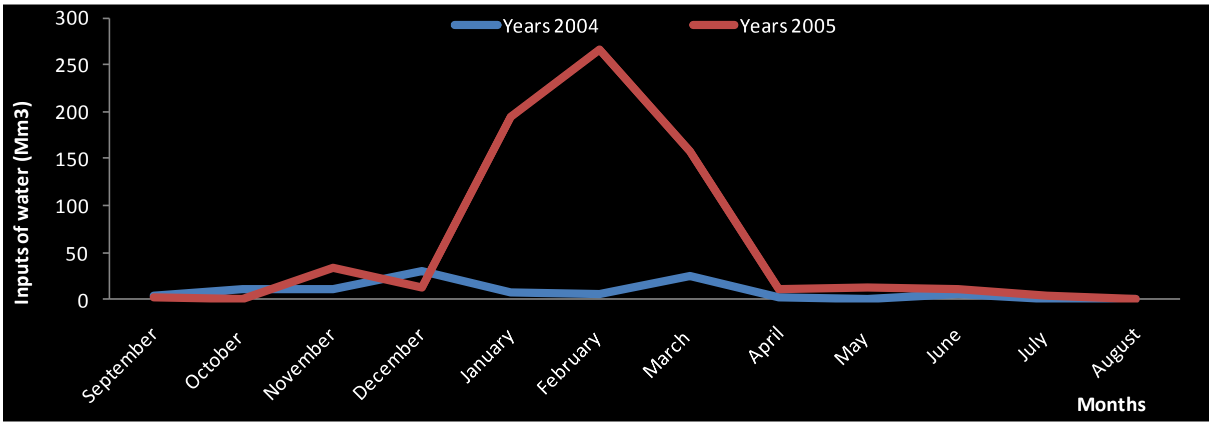

Figure 2: Hydrological means inputs of water (Mm^3) registered during the years 2004 and 2005 of the SMBA dam

4.2. Fe and Mn concentrations in surface and bottom waters

The evolution of the levels of Fe and Mn in the waters in our study showed of seasonal and inter-annual little significant variation in surface and very irregular at the bottom. They were influenced by physical and chemical factors [12].

4.2.1. Average Levels of Fe in surface and bottom waters during 2004 and 2005

The maximal in surface showed a minimum of the order of 0.009 mg/l recorded during 2004 which would be reduced to a value of the trace order in 2005. However, a maximum content was recorded in the year 2004 with a value of the order 1.4 mg/l which would be reduced to a value in the order 1.2 mg/l in years 2005.

Levels at the bottom showed the most remarkable seasonal variation which these varied between a minimum of the order which would be increased to a value of the order 0.01 mg/l during the years 2004 and 2005 respectively and the maximum was recorded during 2004 with a value of the order 4.1 mg/l which would be reduced to a value of 1.35 mg/l during the years 2005. Therefore, it can retain that concentrations of Fe in the bottom waters are higher compared to those in surface with the exception of a few points where there detected levels inversed (**Fig. 3**).

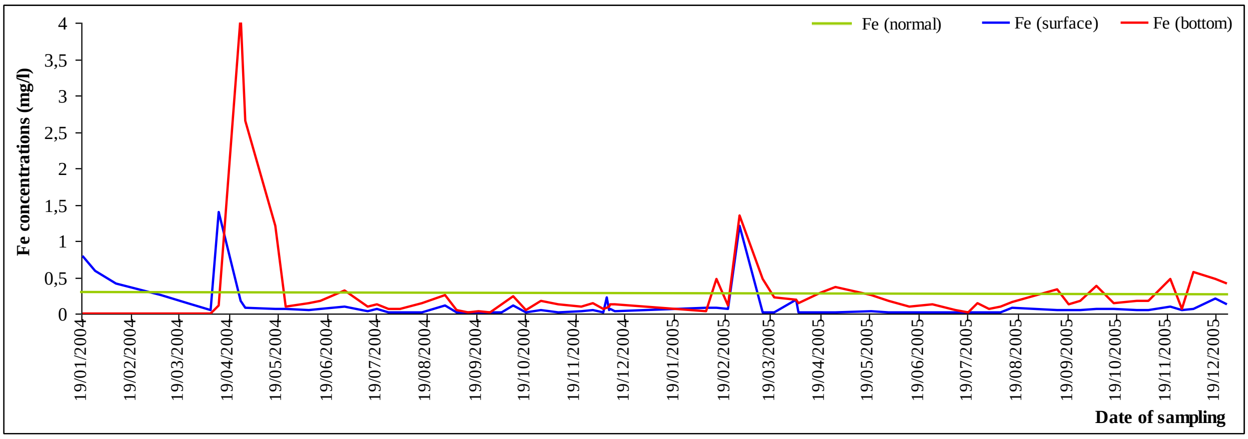

Figure 3: Seasonal variation of Fe in the surface and bottom waters in SMBA dam

4.2.2. Average Mn in surface and bottom waters during 2004 and 2005

Levels of Mn in the surface and bottom waters behave in the Dam in the same way as the Fe. Indeed, they varied in surface between a minimum of the order at the trace of winter in 2004 and at the end of the summer in 2005 and the maximum was noted in 2004 with a value 0.46 mg/l value that was passed to 0.55 mg/l in 2005. At the bottom of the Lake of our Dam, the values showed important inter-annual and seasonal variations. Indeed, the minimum concentration of Mn varied from 0 mg/l, noted during 2004, and a value of 0.009 mg/l detected during the year 2005. The maximum was of 1.7 and 0.73 mg/l respectively recorded during the years 2004 and 2005 (**fig. 4**).

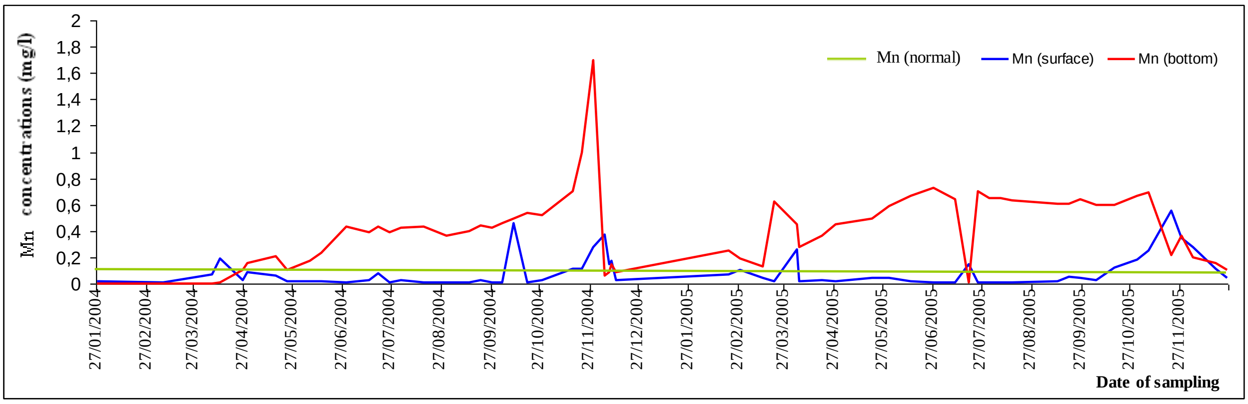

Figure 4: Seasonal variations of the Mn on surface and bottom during the years 2004 and 2005 in SMBA dam

The highest values of the Fe and Mn were due to the phenomenon of thermal stratification during the dry period or flood or inputs which are loaded with organic and mineral mutter during periods of adverse. However, the lower of these concentrations were due to the artificial destratification in winter [13, 14].
Concentrations of Fe and Mn at the bottom were higher than those in surface with the exception of a few points where the reverse was noted.

4.3. Fe and Mn comportment in the SMBA dam

The variation of the temperature between the surface waters with those of the bottom in each hydrological year shows the formation of three thermal strata of water [15, 16].
The upper layer or epilimnion is airy, received more light and heated during the summer. It is the seat of an intense life. The green algae that proliferate in this layer, consume the dissolved CO_2 and release dissolved oxygen. Fe (II) is much more soluble, but is quickly oxidized in surface waters [17, 18].

The layer of transition or mesolimnion whose a dissolved oxygen content decreases from the surface to the bottom of this zone.
The deep layer or hypolimnion which is totally devoid of dissolved oxygen. This zone is the seat of anaerobic fermentation. Some bacteria release hydrogen sulfide and other such as methane by the decomposition of plants that accumulate at the bottom.
According to this vertical cutting, the decomposition of the organic matter of endogenous or exogenous origin in the hypolimnion zone requires the consumption of dissolved oxygen and subsequently makes bottom devoid of oxygen. However, the anaerobic fermentation promotes the release of undesirable elements at the bottom, including of Fe, Mn and sulfide hydrogen [19].
In contrary, the Fe and Mn can oxidize easily depending on the pH at the level of the epilimnion layer which is the more oxygenated and as they gather with other more complex elements which have physical properties for their precipitation at the bottom under the gravitational effects.
Fe and Mn concentrations decrease during in the season the fall. This phenomenon is due to oxidation by oxygen, the homogenization through the regime of winds and brewing of the withholding of the dam. When the water temperature of the surface decrease, the epilimnion waters decrease but the bottom layers reassemble to the surface. In winter, the levels in question become important because of the runoff coming from the versant basin to the restraint of the dam. The noticed phenomena at the beginning and end of the spring are similar to those recorded at the end of winter and the beginning the summer successively.
These seasonal processes explain the flow caused by the temporal and spatial variations in the restraint of the dam [20].

4.4. Classification of the levels of Fe and Mn in our study on the water quality grill

Qualitatively, the quality of surface waters of the SMBA dam is generally good for Fe contents. However, it was slightly for the Mn levels in the year 2004 and bad in 2005 exceeding the standard of quality of surface waters intended for the production of drinking water (**Tab. 1**). This state of fact requires advanced treatment to make this dam water drinking and take the necessary measures to fight against any phenomenon causing alteration of the retention of this [13].

Table 1: Classification of our result with that of the Moroccan Grill

Waters types		A1		A2		A3	
		G	I	G	I	G	I
Mn (mg/l)	Morocco limit	-	0.1	0.1	0.1	1	-
	Mean levels in 2004	-	-	-	0.16	-	-
	Mean levels in 2005	-	-	-	0.26	-	-
Fe (mg/l)	Morocco limit	-	0.3	1	2	1	3
	Mean levels in 2004	0.22	-	-	-	-	-
	Mean levels in 2005	0.17	-	-	-	-	-

For the categories of drinking water are to be:
* Class: A1 requires a simple physical treatment and disinfection by filtration.
* Class: A2 requires treatment physical, chemical disinfection.
* Class: A3 requires physical, chemical treatment pushed, a refining and disinfection.

4.5. Typology of the variation of Fe and Mn in our Dam

In aims to synthesize the results obtained and different trends, correlations and other phenomena involved in packaging the presence of Fe and Mn in the SMBA dam and thus identify a typological structure of this quality, we used PCA standard on all the data collected at the level of the dam during the study period (2004-2005).

4.5.1 Correlations of variables with the axes [F1] and [F2]

Correlations of Fe on the surface (FeS), Fe at the bottom (FeB), Mn in surface (MnS) and Mn at the bottom (MnB) on axes [F1] [F2] represent these variables on the correlation of variables (**Tab. 2 and Fig. 4**).

Table 2: Correlations of variables with the axes [F1] and [F2].

Variables	Code	Axe F1	Axe F2
Fe in surface	FeS	-0.77	0.17
Fe at bottom	FeB	-0.28	0.77
Mn in surface	MnS	0.52	0.57
Mn at bottom	MnB	0.79	-0.15

The plane of projection F1xF2 (**Fig. 5**) shows that Fe and Mn contents in surface and at the bottom are well represented on the circle of correlation, indeed:

- The factorial axis [F1] is well correlated with Mn at the bottom (0.79) and the Fe in surface (0.77). A medium correlation with Mn was recorded in surface (0.52).

- The factorial axis [F2] is well correlated with the Fe at the bottom (0.77) and Mn in surface (0.57) secondarily. These two axes define two different gradients: An enrichment gradient of the Fe in surface opposed the enrichment gradient of the Mn in the bottom by axis [F1]. The second gradient, which testifies to the enrichment of the Fe at the bottom along axe [F2]

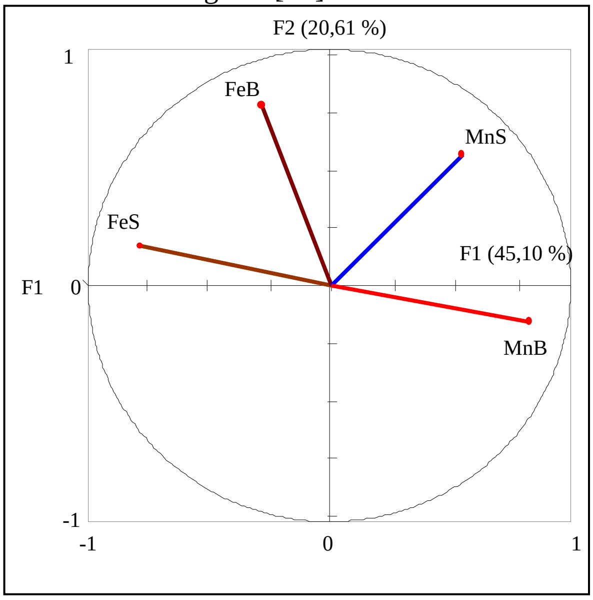

Figure 5: Circle of correlation of variables

4.5.2 Typology of sampling

For each type of variables is a typology of surveys that more clearly identifies the trends that could dominate the annual or inter-annual situation in 2004 and 2005.

The analysis of factorial map allows identifying the following structures (**Fig. 6, 7 and 8**):

- Dissimilar quality between two years hydrological 2004 and 2005 different (**Fig. 6**).

- Individualization of four groups of seasonal levies for each year according to their degrees of Fe and Mn enrichment in surface and at the bottom (**Fig. 6 and 7**).

Indeed, the year 2004 shows overload Fe surface and low levels of Mn at the bottom. The 2005 year appears more enriched in Mn at the bottom and the low Fe content on the surface. This situation is to correlate with a number of particular environmental factor hydrology and important water inputs during 2005 compared with 2004 (**Fig. 1**). Furthermore, spatial and temporal analysis of this hydrology showed important seasonally variation but it was different depending on the year. The analysis of factorial map showed a succession of the seasons depending on the content of Fe and Mn (**Fig. 5**). The quality passed with a winter rich in Fe (surface) to a fall very rich in Mn (bottom). Between these two seasons, spring and summer showed intermediate situations. However, an overload on Fe at the bottom during in the spring 2004 was detected. This phenomenon could be correlated with this dry year and the spring stagnation followed by thermal stratification caused by the difference in temperature of the SMBA Dam. Therefore, the oxidation of organic matter decrease the pH by the production of dioxide of carbon that promote the dissolution of these two heavy metals passing a part in solution in the form of Fe^{2+} and Mn^{2+} from sediments and submerged rocks [9].

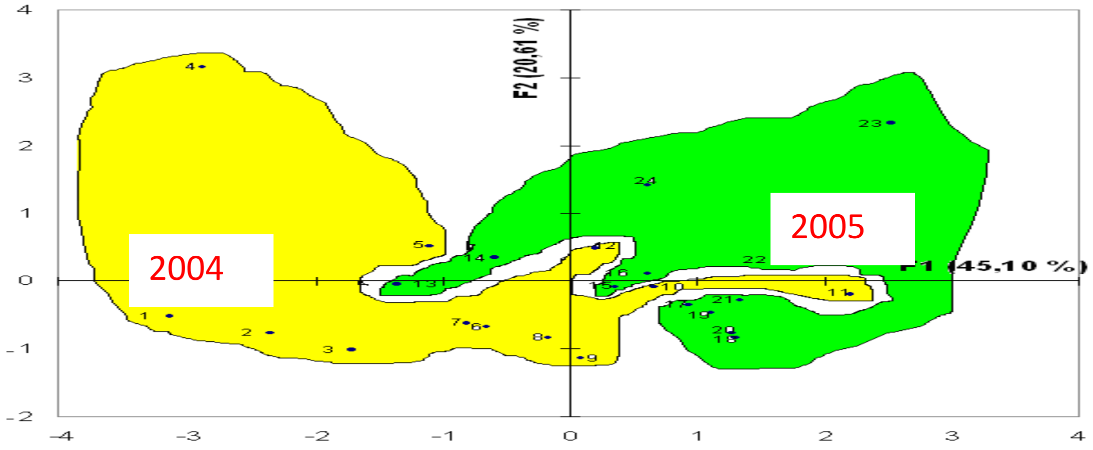

Figure 6: Distribution of variables of Fe and Mn levels in the F1xF2 during 2004 and 2005.

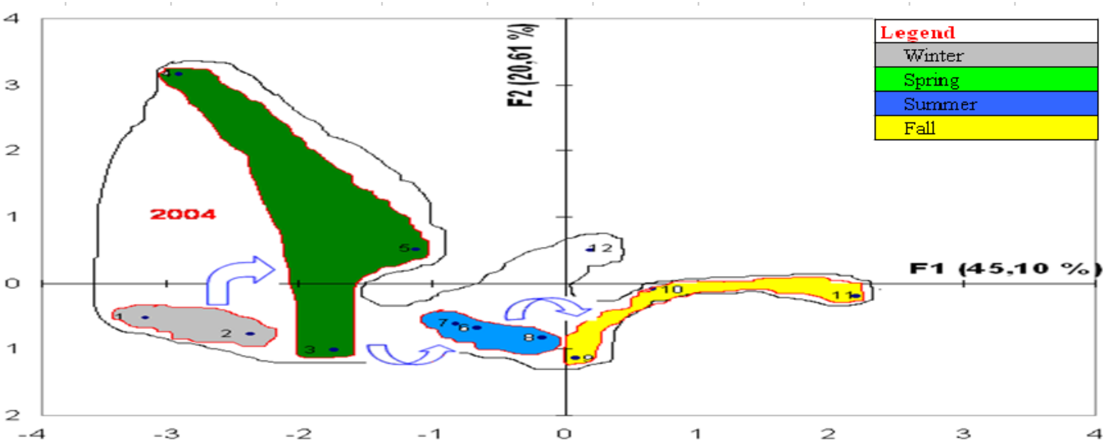

Figure 7: Seasonal distribution of variables of Fe and Mn levels in the F1xF2 for 2004.

Also for the year 2005, the analysis of this situation **(Fig. 7**) showed a succession of the seasons different from that obtained for the year 2004. The year 2004 is characterized by stability and quality average during the winter, spring and summer. An exception of the fall, in 2005 where we found excessive Mn in surface. This could be related at two phenomena: firstly, a decrease of oxygen in the water during this date column. Secondly, a homogenization of the restraint of the dam by the effect of turbulence cried by the endogenous and exogenous factors.

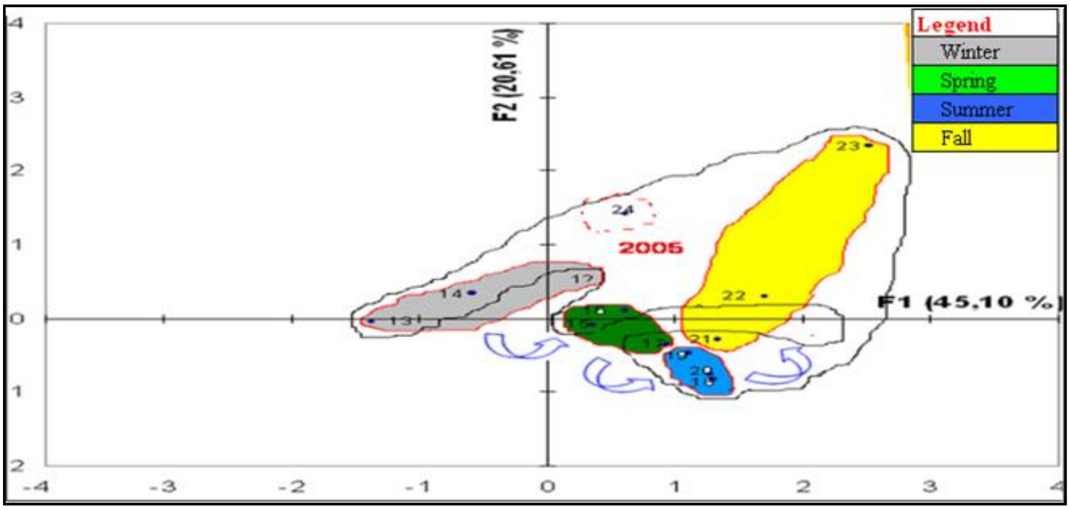

Figure 8: Seasonal distribution of variabless of Fe and Mn levels in the F1XF2 for 2005.

Conclusion

In the light of this study, Fe is marked on the surface by seasonal variation important except for winter and spring during year 2004. Furthermore, these levels are remarkable at the bottom whose the most appreciable values are identified during the spring of the same year. Mn in surface of this SMBA Dam showed important seasonal variations and is irregular at the bottom. For the year 2005, the evolution of Fe content in surface showed seasonally very important variations. They are moderately remarkable at the bottom whose most significant values are identified during the late winter and early spring and autumn season. Furthermore, the Mn concentrations in surface showed important seasonal variations with the exception of some point where there were significant values. Contrary at surface waters, deep waters showed important variation of the Mn that sometimes exceed the standard of quality of surface waters. The study of the comportment of these two metals through the analysis of data collected during this period allowed us to deduce the large variations, recommendations and future prospects.

References

1. El Morhit M., Fekhaoui M., Serghini A., El Blidi S., El Abidi A., Yahyaoui A. *Larhyss Journal* 12 (2013) 7.
2. El Morhit M., Fekhaoui M., El Abidi A., Yahyaoui A., Hamdani A. *D.S.T.* (2012) 8.
3. Emberger L. *Al Awamia* 12 (1964) l.
4. Youssef M. Thèse de doctorat, F.S.R. Université Med V –Agdal, 250p (2009).
5. Davison W. *Eath Sci.* 34 (1993)119.
6. Michard G. Chimie des eaux naturelles, Ed, Publisud, Paris 480 p (2002).
7. Foutlane A., Boulaoud A., Ghedda K. Proceedings of Rabat Symposium S4, April-May. *IAHS Publ.* 243 (1997) 287.
8. El Ghachtoul Y., Alaoui Mhamdi M., Gabi H. *Rev. Sci. Eau* (2005) 75.
9. Boust D., Habert D., Rosert M., Ouddane B., Martin E, skiker M., fischer J. C., Boughriet A., Wartel M. *Rapport Seine-Aval-Thème Dynamique des contaminants,126,* (1998).
10. Laouina A., Coelho C., Ritsema C., Chaker M., Nafaa R., Fenjiro I., Antari M., Ferreira A., Van Dijck S. *Sécheresse* (2004) 65.
11. Ben Mohammadi, A. Thèse du 3ème cycle, Université Mohammed V, Fac. Des Sci. Rabat. 244p (1991).
12. Boust D. *Rapport Seine-aval - thème dynamique des contaminants,* 12p, (1997).
13. National office of drinking water. 41p, (1991).
14. Burns P. L., Powling I. J. Conference series N°2 (1981).
15. Michard G., Jezequel D., Voillier E . *Rev .Sci. Eau* 1602 (2002) 199.
16. Lilita V. These de doctorat en oceanologie. Université de la Méditerranée - Aix-Marseille II. p 5-7 (2008).
17. O'Sullivan D.W., Hanson A.K., Miller W.L., Kester D. R. *Limnol. Oceanogr.* 36 (8) (1991) 1727.
18. Gledhill M., Van Den Berg C. M. G. *Mar. Chem.* 50(1-4), (1995) 51.
19. Van Cappellen P., Wang Y. *Am. J. Sci.*, 296 (1996) 197.
20. Avoine J., Boust D., Guillaud J-F. Rap. 5° Réun.Cons.Int.Explot.Mer. 186 (1986) 392.

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