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Faecal coliforms and faecal streptococci community in the water of SidiChahed dam and these emissaries Mikkes and Mellah (Morocco): the importance of some environmental chemical factors

Smahane Mehanned*, Abdelkader Chahlaoui, Abdelhamid Zaid, Mohamed Chahboune, Radouane EL Moustaine

Team of Management and valorization of Natural Resources, Laboratory of Environment and Health, Faculty of Sciences, Department of Biology, University Moulay Ismail, BP 11201 Zitoune, Meknes, Morocco

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Abstract

A bacteriological and chemical study was carried out within 1 year, from December 2012 to November 2013, on sidiChahed dam and these emissaries Mikkes and Mellah upstream of the SidiChahed dam of Morocco. It assessed the importance of some chemical factors on some faecal bacterial communities. The monthly average densities of faecal coliforms and faecal streptococci varied, respectively, from 3 to 1820 CFU/100mL, and from 0 to 6734 CFU/100 mL of water. These bacterial abundances undergo spatio-temporal fluctuations. Most of the chemical characteristics of these waters are relatively stable with time, with respect to apparent spatial fluctuations. The degree of correlation between chemical parameters and the abundance dynamics of isolated bacteria is high heterogeneous. In our study constituted two wadi and dam, the increase in SDS, electrical conductivity not favored the abundance of faecal coliforms and faecal streptococci.The principal component analysis (PCA) showed that the indicator of fecal contamination have a significant negative correlation with pH, electrical conductivity and TDS and the high significant positive correlation with temperature.

***Corresponding Author:** Smahane Mehanned ✉ smahane_mehanned@hotmail.com

Introduction

The importance of water resources is well established, its management at all levels is imperative. Morocco is a country in climate mainly semi-arid to arid, directly by precipitation. Characterized by strong rainfall contrast between winter and summer.

During the last three decades, Morocco has experienced several prolonged droughts. The effect of these years of drought on water availability basins has greatly exacerbated the deficit in water flow observed since1970; the beginning of the deficit cycle across the whole country (Mokhtar, 2004).

The Sebou basin is among the catchment areas most significant in Morocco, it shelters until our days ten stoppings with contributions out of water rise to 5.010 million m 3 per annum, of which the stopping SidiChahed which makes put out of water in 1997 with a contribution out of water of 170 mm 3 (ABHS, 2011). The vocation of water of the stopping is primarily the drinking water and the irrigation.

The management of water as a resource essential to the human society becomes a real challenge. In Morocco, country with arid semi climate, the supply drinking water and industrial is assured primarily by surface water. Since the Sixties, forty dam were built. The water pollution due to micro-organisms of fecal origin appeared very early as soon as water was used as vector of the waste disposal (George and Servais, 2002). However, when the aquatic environment receives rejections of animal or anthropic origin, the number and the type of bacteria present are able to make water unsuitable to the human use (Hébert and Légaré, 2000).If the construction of these works constituted a need well to guarantee, in any season, the supply water essential to our country, it was advisable to control and safeguard the quality of the water retained by these stoppings (El Ghachtoul and *al,* 2005).

The chemical characteristics of environment such as pH, ionic strength, mineral elements and the nature of solid particles influence the bacterial distribution, the amplitude of this influence varying with the considered bacterial species (Fowle DA. *et al.*,2000.4; Yee N. *et al.*, 2000). The bacterial feeling at the chemical environment depends upon the number and the properties of groups of functional sites on its surface, and the disposal sites number can vary with chemical features of the biotope (Fein JB.*et al.*, 1997). Finally, this work is aimed at analyzing the waters running of the two emissary and sidi Chahed dam, the importance of some chemical parameters on the distribution of faecal coliforms and faecal streptococci, two bacterial groups of a high hygienic importance.

Materials and methods

Study area

The dam Sidi Chahed located in the Saïss plain between Meknes and Fèz (Morocco) which is characterized by a semi-arid climate with subhumide of the area. The site of the sidi Chahed dam is located on the Mikkés Wadi and the Mellah Wadi with the tightening of the place says Sidi Chahed, toapproximately 10 km of the principal road n°3, connecting the town of Fès to the town of SidiKacem by a track of 3Km length (Fig.1).

The stream Mikkes is a tributary of the stream This article highlights the relationship between River Sebou. Its waters are regulated by the dam of SidiChahed. Its catchment area is located between the cities of Fez and Meknes. The region contains the cities of Ifrane, AïnTaoujdat and many other centers. Its area about 1600 km2 (Fig. 1).

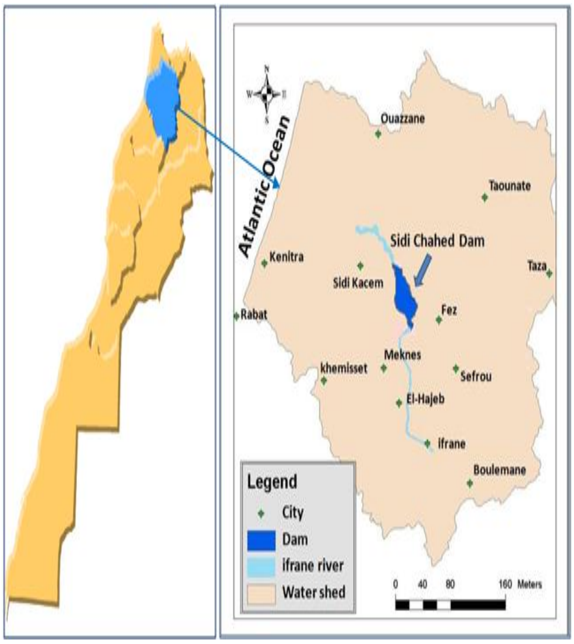

Fig. 1. The study area.

The basin of Mikkès is drained by four affluents: N' ja Wadi and Atchane Wadi out of right bank, TizguitWadi and AkkousWadi out of left bank. The two first drain the plain of Know and the two last drain theplate of Meknès and the causse El Hajeb – Ifrane. The basin is characterized by a rather significant number of sources which emergent in varied contexts hydrogeologic (Fig.2).

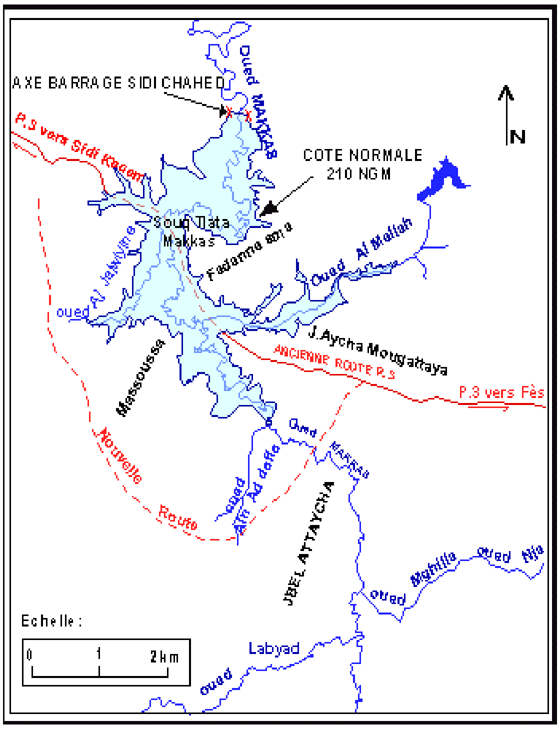

Fig. 2. Hydrological map of Sidi Chahed dam.

To highlight the influence of the medium surrounding and the anthropic activities on the bacteriological quality of the water of the reserve of the SidiChahed dam, we chose four stations whose one station(S b) represents the whole of the water column of the lake reservoirSb and the three SMi stations, SMe, SI, respectively indicates the surface of the MikkésWadi, the surface of the MellahWadi, and the point which joined the surface of the two Wadis (Fig.3).

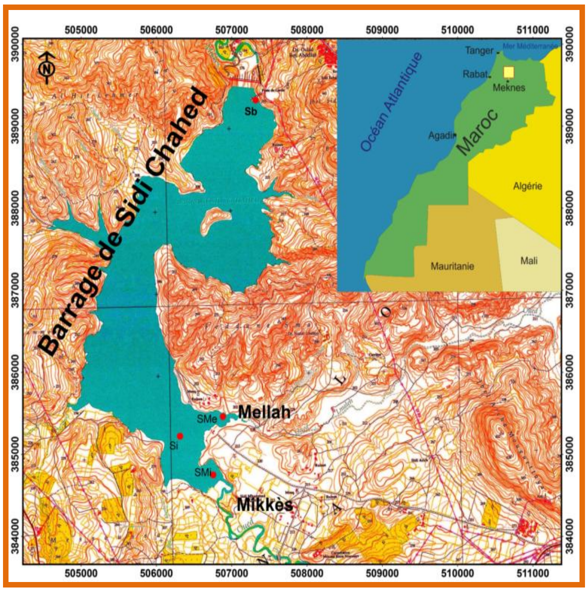

Fig. 3. Localisation of sampling sites.

The area of study covers three different structural sets: El Hajeb-Ifrane Tabular in the South. The Saïs basin in the centre and Prerif in the North

The El Hajeb-Ifrane Tabular is a free-water table circulating in the dolomitic and limestones formations of the lower and middle Lias outcrop, which is supplied directly rock salt separate these formations from the Paleozoic substratum.

At the Northern limit of the Tabular Atlas, the limestones and dolomitic formations sink toward the North, under the Fez-Meknes Neogene basin and rest on the Southern Rif Substratum.

Under the Fez - Meknes basin, the structure of the Lias is very apportioned by faults and flexures wher some of which appear at the surface. The superficial layer is marly Miocene series keeping the Lias groundwater under pressure; the Saïs confined aquifer. Resting over these series, a complex of Plio-quaternary formations (sands and limestones…) hold the superficial groundwater communicates through the faults and flexures or through the semi - permeable marly layers level (Latati, 1985) (Fig.3).

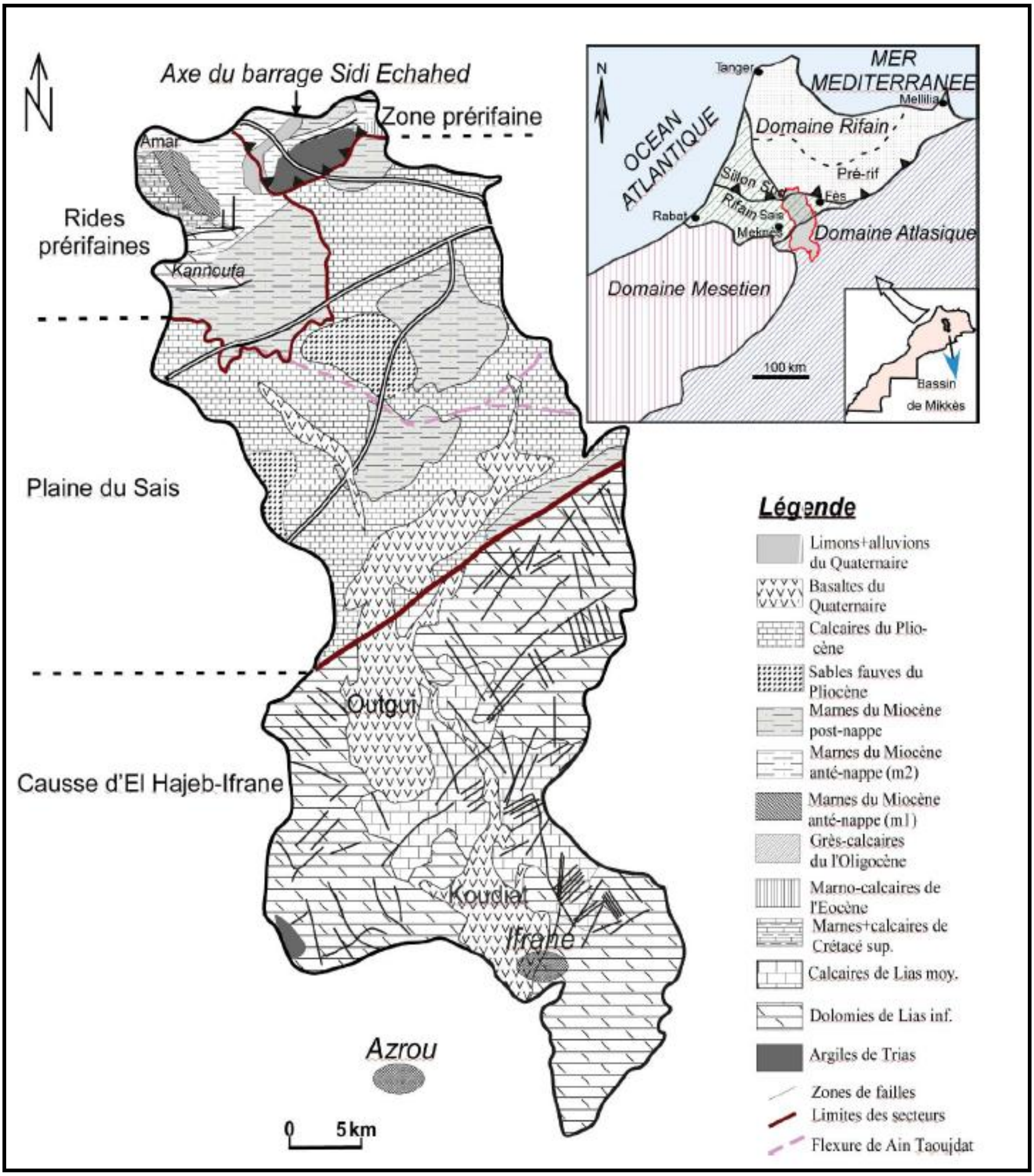

Fig. 4. Geological map of the catchment area of Mikkès (extracted the geological map 1/100 000, Reduction, Morocco, 1975).

Sampling and analytical methods

The samples were taken according to standardized techniques: using a Van Dorn-shaped bottle (volume: five liters) for physico-chemical analysis, and sterile glass bottles (volume: 500 milliliters) for bacteriological analysis. Both of which have been previously sterilized by autoclaving. All these samples were collected and transported to the laboratory according to the usual procedure (Rodier *et al.*,2009).

The main chemical parameters analysed were pH, SDS and electrical conductivity. These parameters were chosen in accordance with its general importance on the bacterial metabolism. These analyses were carried out according to the techniques described by (Rodier *et al*, 2009).

The isolation of total coliforms, faecal coliforms and faecal streptococciwas carried out by the membrane filtrationtechnique using the Gélose lactose with the including all taxes and Tergitol 7and Slanetz-Bartley media, respectively. Results are expressed as the number of colonies forming units (CFU)/100 mL of water(Rodier *et al*,2009).

Statistical analysis

PCA reflects both common and unique variance of the variables and may be seen as a variance-focused approach that reproduces both the total variable variance with all components as well as the correlations. PCA is far more commonly used than principal factor analysis. In all the Principal component analysis generated two significant factors (Fig.7). Factor analysis is a multivariate analytical technique, which derives a subset of uncorrelated variables called factors that explain the variance observed in the original data set (Anazawa and Ohmori, 2005; Brown, 1998).

Cluster analysis

Cluster analysis is the method used for finding different classes and groups within the obtained data. A number of studies used this technique to successfully classify water samples (Alther, 1979; Williams, 1982; Farnham*et al.*, 2000; Alberto *et al.*, 2001;Meng and Maynard, 2001). The cluster analysis is a group of multivariate techniques whose primary purpose is to assemble objects based on the characteristics they possess (Danielsson, 1999).

Results and discussion

The average monthly densities of total coliforms varied from 112 to 9590 CFU/100mL,from 15 to 9236 CFU/100 mL and from 47 to 1927 CFU/100 mL in the Mikkeswadi, in the Mellahwadi and intersection respectively. Although the rate of fecal coliforms is relatively low compared with total coliforms. Therefore the average monthly densities of faecal coliforms varied from 25 to 432 CFU/100mL,from 7 to 1820 CFU/100 mL and from 3 to 82 CFU/100 mL, in the Mikkeswadi, in the Mellahwadi and intersection respectively (Fig.5).The average monthly densities of faecal streptococci in the two wadsvaried from 0 to 5620 CFU/100 mL and from 1 to 305 CFU/100 mL in the (Fig.5). The abundance of these bacteria undergoes high temporal fluctuations, the standard deviation being sometimes relatively high. These faecal bacteria were sometimes low depending on seasonal variation at times, were sometimes low depending on seasonal variation mainly during the dry season principally.

In the wadis, the pH varied from 7.57 to 9.2 and the electrical conductivity (EC) from 1450 to 1895 µS/ cm. The concentration of original salinity ions varied from 752 to 967 mg/L for TDS.The results show that Mellah wadi had the highest annual electrical conductivity value.This could be explained by the geological field through, green marl past lenticular gypsum called "Marnes green gypsum (Taltasse, 1953).

The pH varies from 7.57 to 9.07 in the study area. These values indicate water from medium neuter to alkaline, with the lowest mean value (7.57) measured in the lake reservoir and the electrical conductivity from 1453 to 1940µS/cm. Compared to other works, the salinity concentrations are higher than those reported by Chahboune *et al.* (2014) at Lake reservoir Hassan II (Morocco) and Ohmidou *et al.* (2013) at Lake Hassan Dakhil (Morocco). The annual averages of these chemical parameter values were calculated in each well point and are presented in(Fig.6).

The relationship between bacterial dynamics and the water salinity, concentration in Na^{+}, K^{+}, Cl, appears to be related to local biotope. It clearly visible in our results between the two wadis and dam (Fig.7). It is known that Na+ and K^{+}intracellular concentrations increase with an increase in K^{+} of the environment (Pelmont J. 1993). These ions can favour the adsorption of other ions such as Fe^{3+} and Al^{3+} especially in acidic environment (Dommergues *et al.*, 1970). Increase in salt concentration in a medium at times can minimise the inhibition by irradiation of some bacterial species such as Escherichia coli (Fujikawa H, *et al*,. 1992)

The difference between the influence of environmental factors in these wadis mother biotope and the dam mother biotope may result in a high and variable vulnerability in well water points with respect to study station and the human impact. In these wadis and dam, the degree of influence of a given parameter on another may be the result of multiple interacting factors, sometimes known by the term "confusion factors". However, in wadis water, the result of the interaction network undergoes a high variability. This may be at the origin of a high ecological instability of faecal coliforms and faecal streptococci in these wadis

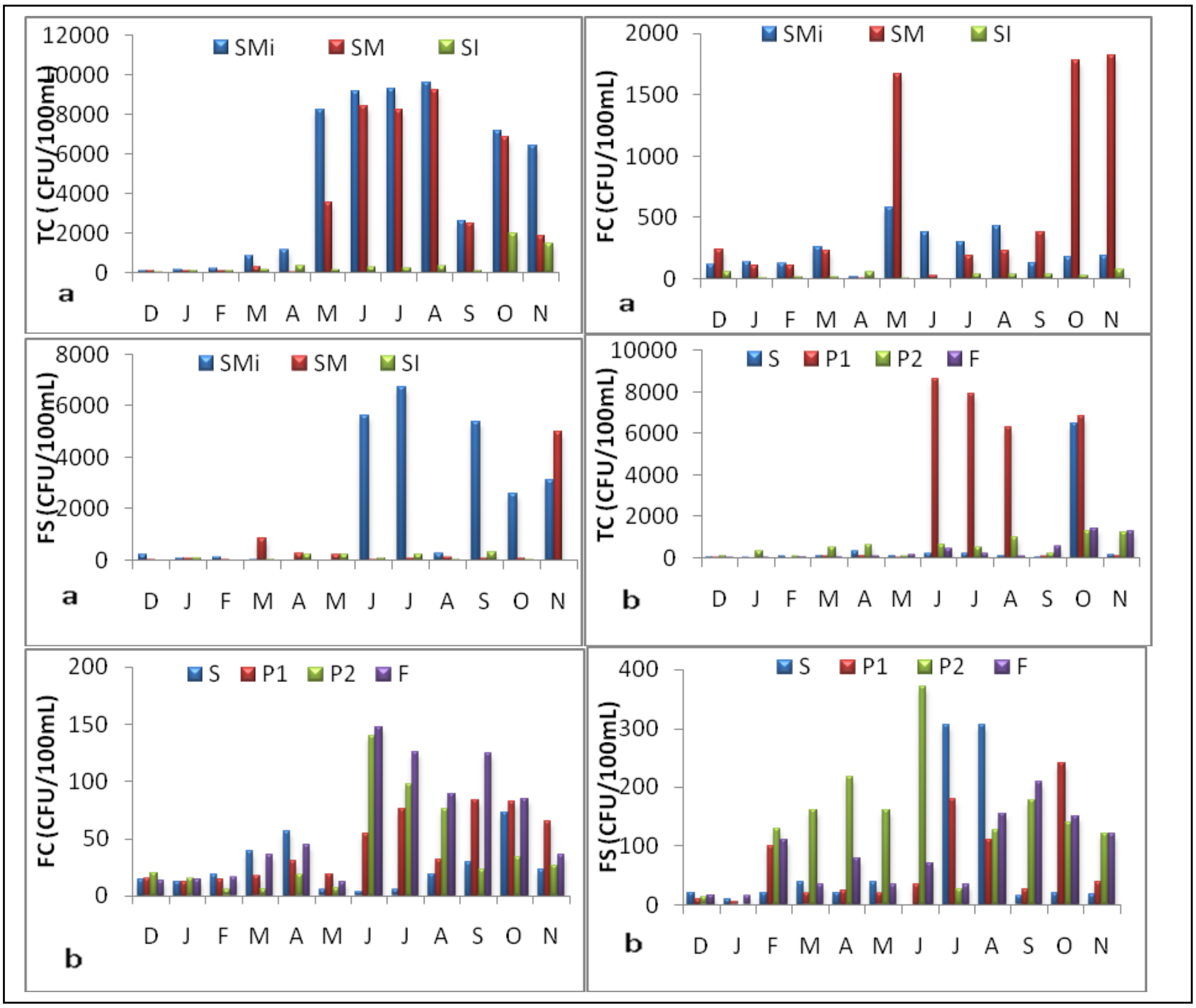

Fig. 5. (a) Monthly average density of FS: faecal streptococci, FC: faecal coliforms and CF: total coliforms in three stations SMi, SM and SI. (b) Monthly average density of FS, FC and CF in for stations S(surface), P1(depth-10), P2 (depth-20), F (melts)of Sidi Chahed dam.

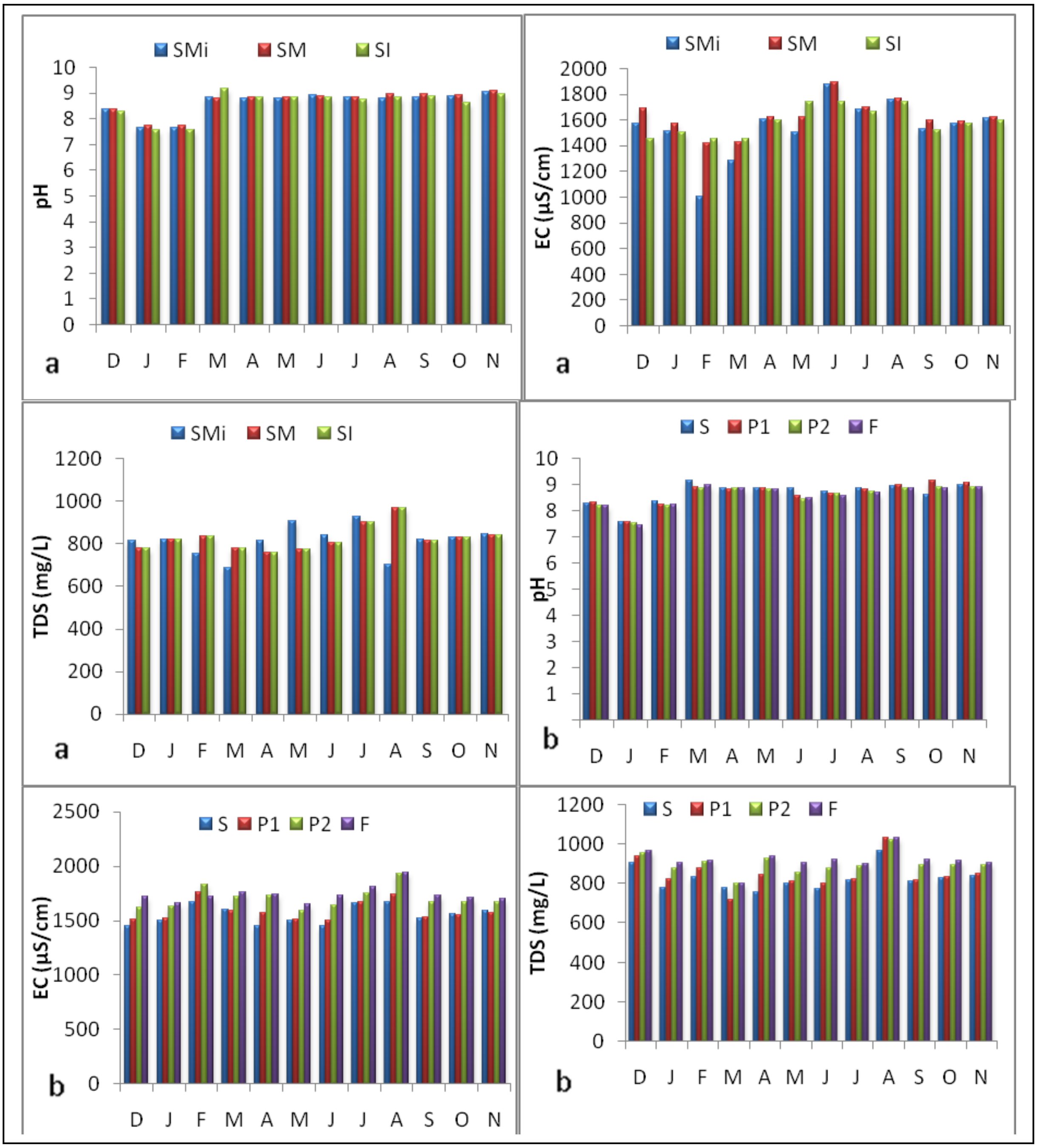

Fig.6. (a).Monthly average of some chemical parameters EC: Electrical conductivity, pH and TDS: Salinity in three stations SMi, SM and SI. (b) Monthly average values of EC, pH and TDS in for stations S (surface), P1 (depth-10), P2 (depth-20), F (melts)of SidiChahed dam.

Pearson correlation coefficients

The close inspection of the correlation matrix was useful because it can point out associations between variables that can show the overall coherence of the data set and indicate the participation of the some chemical parameters and bacteriological parameters in several influence factors, a fact which commonly occurred in hydrochemistry (Helena *et al.*, 2000). The Pearson correlation coefficient matrix is given in the Table 1. The variables having coefficient value (r) >0.5 are considered significant. Inspection of the table reveals that EC is positively related with TDS and pH with °T. The same matrix gives the maximum variance as shown in the principal component analysis-factor 1.

The Spearman correlation test was done using the data obtained from 7 samples collected. The results show that the degree and the nature of the relationship between the abundance of each group of bacteria and the evolution of the concentration of each chemical parameter analyzed are heterogeneous (Table.1).There was a significant negative correlation of (-0, 52) between TDS and FC, therefore this correlation is (-0, 55) between TDS and TC. There is also a small but significant correlation negative between TDS and FC (- 0.25).Whereas EC is negatively correlated (-0,91) with pH.

Table 1. Spearman correlation coefficients between chemical parameters and abundance dynamics of faecal coliforms, total coliforms and faecal streptococci in the stationsstudied.

	T(°C)	pH	EC	TDS	TC	FC	FS
T(°C)	1,000000						
pH	**0,730005**	1,000000					
EC	-0,814589	**-0,919365**	1,000000				
TDS	-0,912897	**-0,664143**	**0,795619**	1,000000			
TC	0,706633	0,606325	**-0,501089**	-0,550523	1,000000		
FC	**0,591221**	0,497334	-0,387707	**-0,252394**	**0,818346**	1,000000	
FS	**0,580098**	0,118513	-0,055598	**-0,526584**	0,665314	**0,449120**	1,000000

Principal component analysis

A Principal Component Analysis (PCA) was performed on a data matrix consisting of 7 lines representing the stations and the 6 columns representing physicochemical and bacteriological variables measured or analyzed. The analysis generated two factors which together account for 84.14 % of variance(Fig.7).

The analysis of factorial plans F1-F2 (Fig.8) reveals three major groups of some physico-chemical parameters and bacteriological parametres. The first group (G1) consists for of faecal coliforms, total coliforms, temperature and pH. The second group (G2) is characterized by low mineralization and weak contamination. The third group (G3) is formed only by EC and TDS.

Analysis of the first Groups G1

The group G1 characterized by a strong contamination, In the wads mother biotope, the high concentration in salinity (TDS) disfavors the population of faecal coliforms, total coliforms and faecal streptococci, compared to the water of the other groups (G2 and G3)(Fig.8).

Analysis of the second groups G2

In this group G2, the water is characterized by low mineralization and weak contaminationwater compared to the water of the first groups G1(Fig.8).

Analysis of the third groups G3

For this group G3 composed of two stations(P2 and F)situated in Lake Reservoir, the water is characterized by high mineralization(Fig.8). The analysis of the correlation matrix (Table 1) allowed identifying a correlation of 0.79 between two parameters EC and TDS. This high correlation indicates that these two parameters are strongly linked. Indeed, some authors (Demirel, 2007; Pradeep, 1998) showed that the salinity is expressed by the electrical conductivity.The severity of the salinity effect on the microorganisms in the biotope can be accentuated by a low concentration in dissolved oxygen. Then the depth disfavors the exchanges of with atmospheric oxygen.

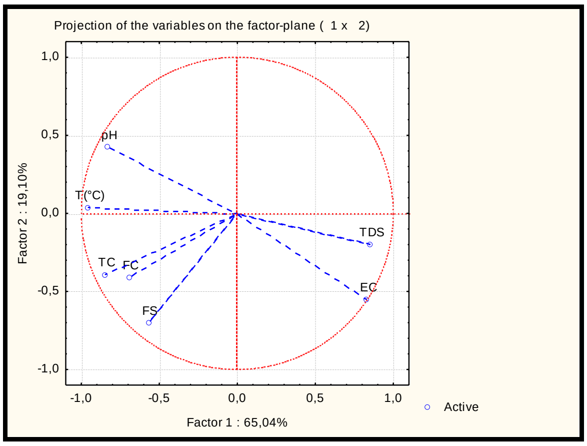

Fig. 7. Projections of physical-chemical variables and bacteriological of F1-F2 factorial plan on the PCA

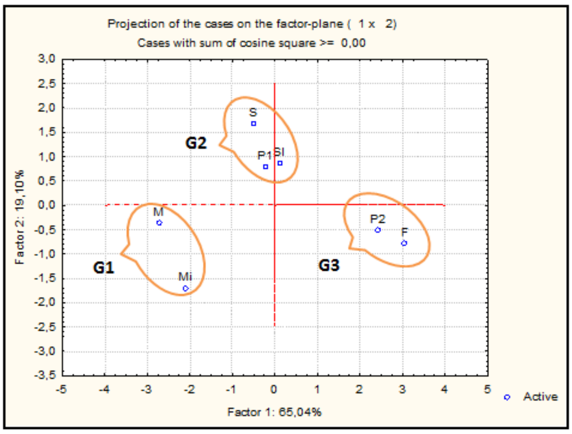

Fig. 8. Grouping of statistical units

Conclusion

The surface water of the lake reservoir Sidi Chahed and these emissaries harbours great faecal bacterial communities. This water is hightly salty, with a high level of mineralization, the pH is basic .Faecal bacterial distribution is influenced by chemical factors. The inhibitory effects of these environmental factors can minimize contamination of the water by these bacteria.

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