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Evaluation of the microbiological quality of the seawater of the main beaches of Skikda (East-Algerian)

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ABSTRACT

Monitoring of physico-chemical parameters and microbiological quality of seawater from the main beaches of Skikda (eastern Algeria) were undertaken from June 2008 to May 2011. The results were processed by multivariate statistical approach. A work plan was adopted to evaluate the water quality of the beaches of the Gulf of Skikda. In the beginning we took samples at 14 stations (beaches), which are grouped into three sub-areas of study: SZE1: Common Skikda with 5 Stations, SZE2: Stora city with 3 stations and SZE3: City of Larbi Ben M'hidi with 6 stations. In our study, we were able to deduce that in both analyzed in the SZE1 (range of green castle) and the beaches in the SZE3 Beach 4 post their waters are acceptable compared to the rest of the beaches that are in good microbiological quality. In general we found in our study that the coastal waters of Skikda are acceptable and comply with Algerian standards [1]. Therefore, strict control of waters of these beaches should be performed during the whole annual cycle and by specialized people, which will allow proper monitoring of these ecosystems. Analysis of variance showed a difference between the 3 years of follow-largest gap is noted for the year June 2008 to Mai 2009. Compared to Algerian standards and those of the OMS/UNEP (1983)[2] relating to recreational water main beaches of Skikda are considered acceptable for swimming with temporary changes in microbiological quality.

Key words: Skikda, pollution, coastal, bacteriology, physics and chemistry.

INTRODUCTION

The pollution of the water due to microorganisms of fecal origin appeared early as soon as the water has been used as a vehicle for the elimination of waste [3]. However, when the aquatic environment receives discharges animal or human origin, the number and type of bacteria are able to make the water unfit for human use [4]. More often, these diseases are transmitted through the faecal-oral route and human contamination is carried out either by consumption of food contaminated with water, or during a bath or a contact with water for recreational use [3].

The Algerian coastal water quality is probably one of the hardest concepts to define, because often the assessment is subjective. However, aspects of safety of sea water have acquired importance in growing, translated in Algeria by legislation regulating the health conditions of recreational waters [1].

Contamination of surface waters by pathogens is a problem that goes far back in time. During IXXe century, waterborne diseases were responsible for large epidemics of dysentery, typhoid and cholera, among others [3]. Today, these diseases are responsible for a very high mortality rate of populations of developing countries. Worldwide, approximately 6 million children die each year from gastroenteritis, 100 million people suffer

permanently from water gastroenteritis, 260 million people are infected with schistosomiasis, 2 to 3 million deaths observed each year among the 800 million malaria patients and 30 million are counted onchocerciasis [5].

Monitoring of Physico-chemical and microbiological water sea beaches Skikda qualities was conducted from June 2008 to May 2011. These recreational sites (Fig. 1) are located in the Gulf of Skikda same time as the Sonatrach petrochemical complex and a major wadi (Saf Saf) are frequented by a large regional population especially in the summer.

Skikda is located in the northeast of Algeria, covers a total area of 4137.68 km^2 with a coastline of 142 km long between the cap and cap Iron Bougaroune, representing 12% of Algerian coast [6] With approximately eighteen (18) discharges, crossed by three major rivers: wadi Kebir to the east, watershed Saf-Saf in the center and wadi Geubli in the west [7]. These three rivers play an important role in ecosystems, in addition to their essential role in irrigated agriculture rivers determine the richness and diversity of flora and fauna of Skikda. Currently, water quality is under strong pressure from population growth and industrial activity [8] (Fig. 1).

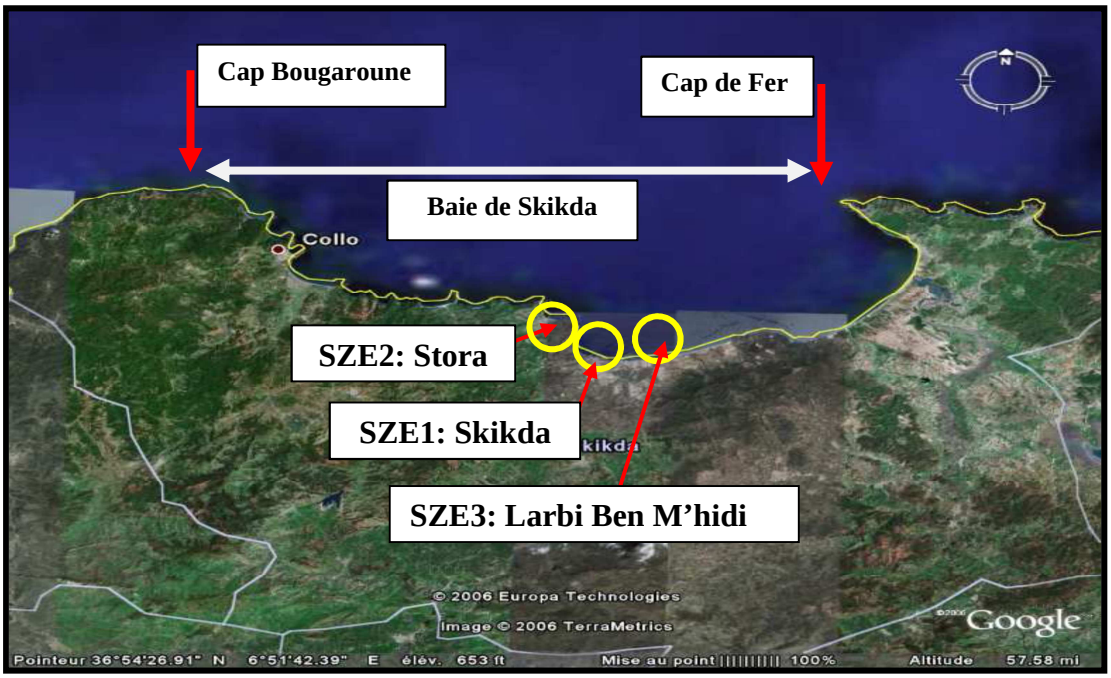

Figure 1. Satellite image showing the location of Skikda (Google Earth amended 2014). The yellow circles represent the three sub-areas: ***SZE 1:*** *Sub Study Area 1 representing the town of Skikda,* ***SZE 2:*** *Sub Study Area 2 is the common Stora* ***SZE 3:*** *Under study area 3 representing the Common Larbi ben M'hidi.*

The objective of this theme is monitoring the level of contamination of bathing waters of the Gulf of Skikda for 3 consecutive years (2008-2011), for the estimation of physico-chemical parameters relevant temperatures, salinity, potential hydrogen, electrical conductivity and dissolved O2 in the surface and the assessment of fecal contamination based on the enumeration of total coliforms, fecal coliforms and fecal streptococci waters. And apply statistical methods to correlate the data from the spatio-temporal variability of the bacteriological quality to the physic-chemical parameters, allowing to provide scientific expertise to local collective for decision support in the management of problems biological pollution.

MATERIALS AND METHODS

1. Site and sampling technique.

Fourteen sampling stations were chosen based on the distribution of urban waste and continental inputs carried by the wadis. Samples were collected in glass bottles of 250 ml. Such ways the neck down to a depth of approximately below the water surface 20 cm, it is then turned slightly adjusted, the orifice in front of e possible current. Once the levy, the capped bottle, labeled and placed in a cooler at a temperature between 4 and 6 °C. Laboratory analysis begins within a period of 8 hours after sample collection. The 14 stations are spread from East to West and their characteristics are shown in three sub-areas (Tab. 1).

Table 1: Representation of sampling stations with their geographic coordinates

St.	In Study Area	Nomenclature of the beaches	Geographic Coordinates
1	**SZE 1:** Skikda	Château vert	36°53'16''N, 6°53'49''E
2		Casion	36°53'18''N, 6°53'39''E
3		Markette	36°53'25''N, 6°53'45''E
4		Militaire 1	36°53'32''N, 6°53'14''E
5		Miliatire 2	36°53'35''N, 6°53'09''E
6	**SZE 2:** Stora	Paradis	36°53'10''N, 6°53'02''E
7		Molo	36°54'16''N, 6°52'50''E
8		Miramar	36°54'35''N, 6°53'10''E
9	**SZE 3:** Larbi Ben M'hidi	Face of the étoile camp	36°53'11''N, 6°58'29''E
10		Poste 1	36°53'15''N, 6°58'11''E
11		Poste 2	36°53'18''N, 6°59'02''E
12		Poste 3	36°53'20''N, 6°59'15''E
13		Poste 4	36°53'25''N, 6°59'32''E
14		Poste 5	36°53'29''N, 6°59'54''E

2. Analysis of samples

Seventy tow samples were monthly taken for 4032 analysis, concerning 5 physic-chemical parameters and 3 bacteriological parameters of each of the 14 stations during 3 successive years since June 2008 to May 2011.

3. Physico-chemical analysis of water

These samples taken were analyzed *in situ* using a probes land type WTW type 197-S [9], to determine the temperature, salinity, pH, electrical conductivity of the water and the rate of O2 saturation.

4. Bacteriological water analysis

Bacteriological analyses of the water samples were determined using multiple tube fermentation method (most probable number) for enumeration of both total coliform count and fecal coliform count. Lauryl Tryptose Broth (LTB) along with fermentation tubes (Durham tubes) was used. A serial dilution of the water sample to be tested was made and inoculated into LTB growth media. Samples were then incubated at 35°C for 48 h for the presumptive test for total coliform count. After the positive tubes were transferred to Brilliant green lactose bile broth (confirmation test) and incubated for 48 h at 35°C, the growth or gas production confirmed the presences of coliform [10]

5. Expression of results

Levies, transport and analysis of the samples of sea water has been made in accordance with the guidelines for the health monitoring of the quality of coastal waters [11].

The collected data are processed statistically and compared to values guides and mandatory fecal germs. This comparison is based on the study of statistical methods of concentrations depending on season, the analysis of variance of the level of contamination on the basis of the years is performed by the test of ANOVA [12]. The experimental values were also compared standards Algerian published in the official journal No. 46 dated 14/07, 1993 [1].

RESULTS AND DISCUSSION

Table 2: Results of physico-chemical analyses of the waters of the Gulf of Skikda from June 2008 to May 2011

Seasons	Temperature	Salinity	pH	Electrical conductivity	Dissolved oxygen
Summer	20,77	37,02	7,95	55,32	93.33
Autumn	15,49	36,46	8.05	53.58	67,84
Winter	14,97	34,75	7.98	51.86	100.48
Spring	19,65	36,08	7.87	54.23	100.63

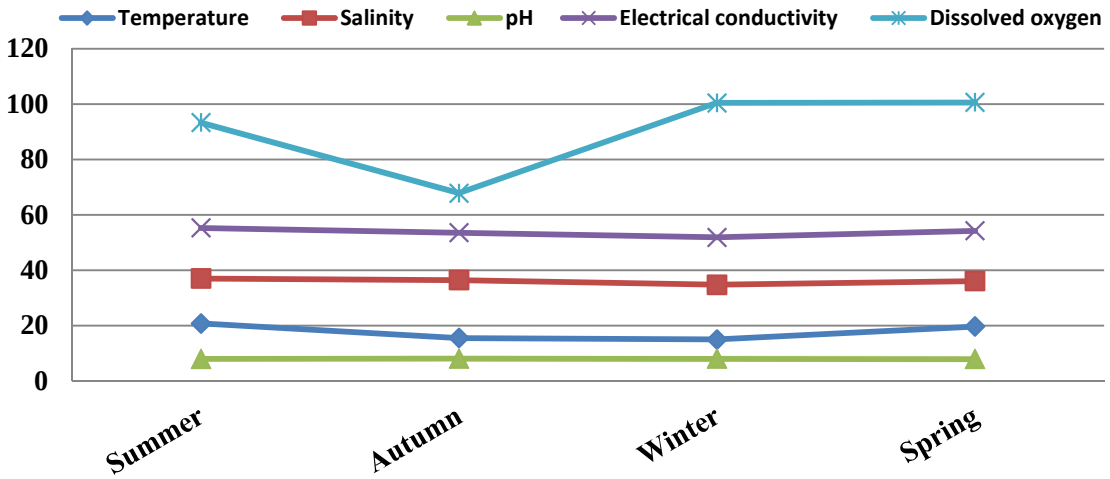

Figure 2. Evolution of physico-chemical parameters of the season

Table 2 shows the seasonal variations in physico-chemical parameters in bathing waters of the Gulf of Skikda from June 2008 to May 2011, **For the temperature,** the maximum value is obtained in summer (Fig. 2) with an average value 20.77 °C (Tab. 2), the temperatures measured during the study period June 2008 to May 2011 were < 25 °C as a limit, putting the bathing water compliance with recommended Algerian standards, and the minimum value was recorded in the winter, this is explained by the strong intrusion of the coast of the Mediterranean basin led to a continuous renewal of these waters. The results remain according with that recorded by Gueddah (2003) of 27.09 °C [13] and that found by Chaouch (2007) of 19.21 °C [14]. **Concerning salinity,** maximum concentrations are measured in summer as a result of the importance of evaporation intensity in strong warming, and minimum in winter (Fig. 2). This result is explained by the dilution of sea water by heavy rains in winter. We can say that fluctuations in salinity are related to climatic conditions. **Regarding the changes in pH** values are within the limits Algerian between 6 and 8 required quality of bathing water. However, all recorded values are between the lower 7.87 and upper 8.05, so these values are comparable to those recorded with other authors of 8.15 for those Gueddah in 2003 [13] and that found by Chaouch (2007) of 7.79 [14]. **Concerning conductivity electrical** values recorded are little mineralized, they are between 51,86 µs/cm as lower limit in winter and 55.32 µs/cm as the upper limit in the summer (Fig. 2), **Regarding the dissolved** O_2, the maximum values are measured in spring order of 100.63%, and the minimum values in autumn around 67.84. These results are still very high compared to that found in 2003 by Gueddah of 50.06% [13] and that found by Chaouch in 2007 about 50.63 [14]. In general, our results show that the physico-chemical of coastal waters of Skikda have no pollution. Their qualities can be considered fitting with Algerian standards.

Table 3: Results of bacteriological analyses of water of the Gulf of Skikda from June 2008 to May 2011
CT: Total Coliforms, CF: Fecal Coliform, SF: Fecal Streptococci.

Periods	Seasons	CT	CF	SF
		(CFU/100 ml)		
June 2008 - May 2009	Summer	234.50	0.07	37,40
	Autumn	181.31	0.14	34,40
	Winter	80,62	0.69	7.57
	Spring	138.33	0.36	48,74
June 2009 - May 2010	Summer	187, 62	0.07	2 7.52
	Autumn	181.31	0.14	34,40
	Winter	80,62	1.02	6, 29
	Spring	117, 29	0.62	48, 33
June 2010 - May 2011	Summer	187.62	0.07	2 7.43
	Autumn	175.00	0.14	2 4.81
	Winter	74,07	1.05	5, 48
	Spring	1 17.76	0.64	36.36

Pollution related to bacteriological water is caused by wastewater from domestic and industrial sources. the variation of total germs shows their dominance during summer (Fig. 3), with average values of order of 234,50 CFU/100 ml as greater concentration in the summer of 2008 and 74.08 cfu/100 ml as lower concentration in the

winter of the year 2011 (Tab. 3). These results remained below not exceeding the guideline value of 500 CFU/100 ml, and 10000 CFU/100 ml as the value limit of Algerian standard [1].

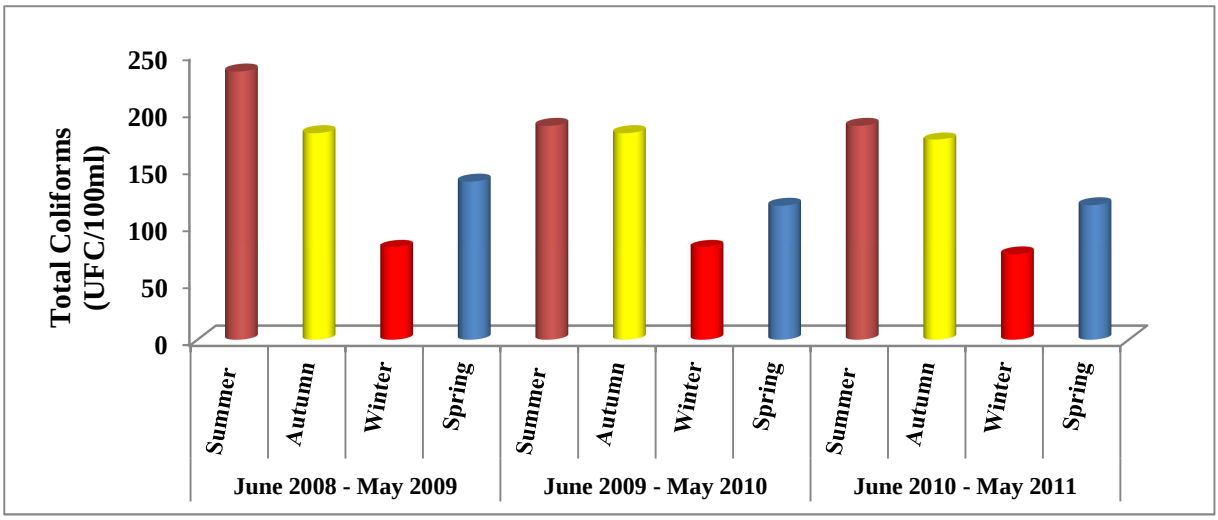

Figure 3. Variations of mean concentrations of total coliforms in sea water

On fecal coliform fluctuations were recorded cramped with a predominance in winter (Fig. 4), with higher mean concentrations of 1.05 UFC/100 ml in the winter of 2011 and lower average concentrations of 0.07 cfu / 100 ml Winter 2011 (Tab. 3). These results are consistent with the standard of Algeria does not exceed the guideline value of 100 CFU / 100 ml or limit value in 2000 CFU/100 [1].

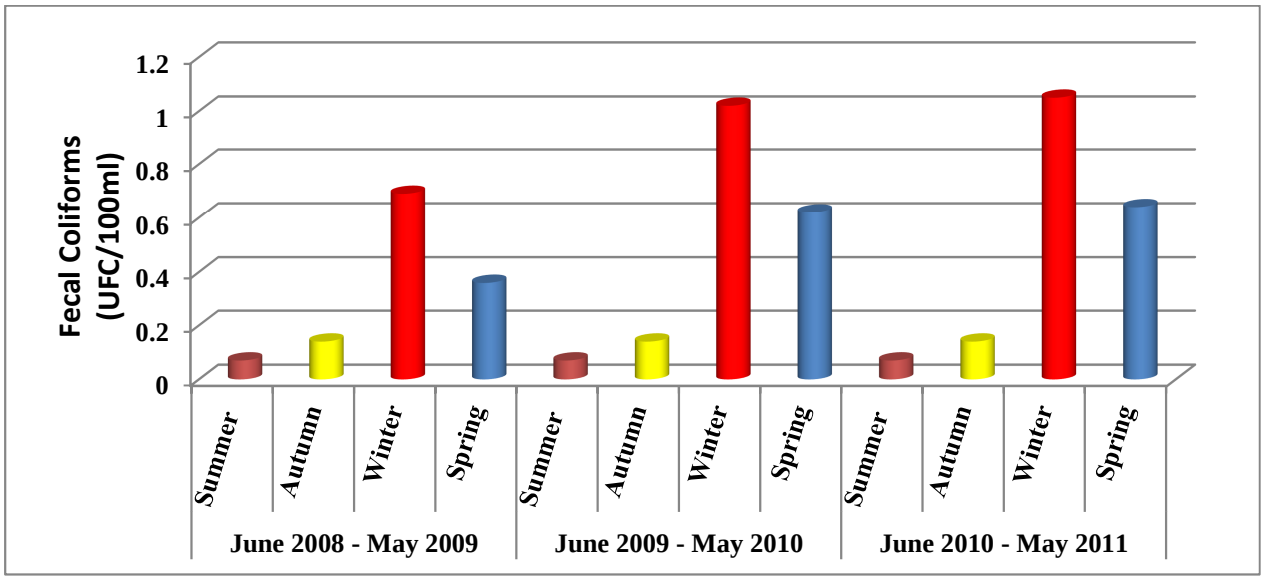

Figure 4. Variations of mean concentrations of fecal coliforms in sea water

Regarding changes in fecal streptococci were recorded predominantly in spring (Fig. 5), with higher mean values of 48.74 CFU / 100 ml in the spring of 2008 and lower average values of 5.48 CFU / 100 ml in the winter of 2011 (Tab. 3). These average concentration does not exceed the limit value is 100 CFU / 100 ml and still conform to the standard of Algeria (from the executive described No. 93-164 of 10/07/1993 JORA No. 46).

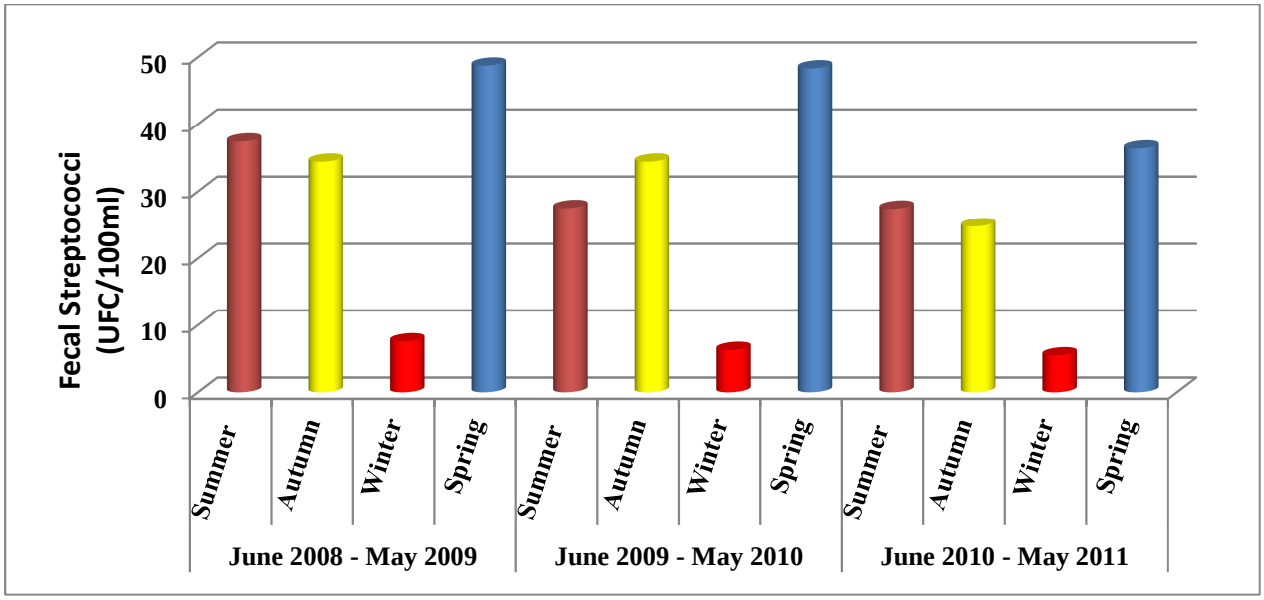

Figure 5. Variation of mean concentrations of fecal streptococci in seawater

Based on this evaluation, the seawater being analyzed is considered acceptable quality for swimming. Fecal streptococci are currently a more significant that fecal coliforms and a better indicator of the safety of recreational water contamination test. This is attributed to their ability to withstand the marine environment [15].

The calculation of the index Bourgeois shows that the study area during June 2008 to May 2009 was mainly animal exposed to pollution in all 14 bathing sites (R <0.7), a except in the range of item 1 of Larbi Ben M'hidi has an uncertain origin (1 <R> 2). And during June 2009 to May 2010 index Bourgeois shows that the study area has been exposed to an animal essentially pollution in all 14 bathing sites (R <0.7), has the except in the range of item 1 of Larbi Ben M'hidi has an uncertain origin (1 <R> 2). While calculating this index period from June 2008 to May 2009 show that the Gulf has been exposed to an essentially animal pollution in all 14 bathing sites (R <0.7), except in Beach station 1 Larbi Ben M'hidi has an uncertain origin (1 <R> 2). (Fig. 6)

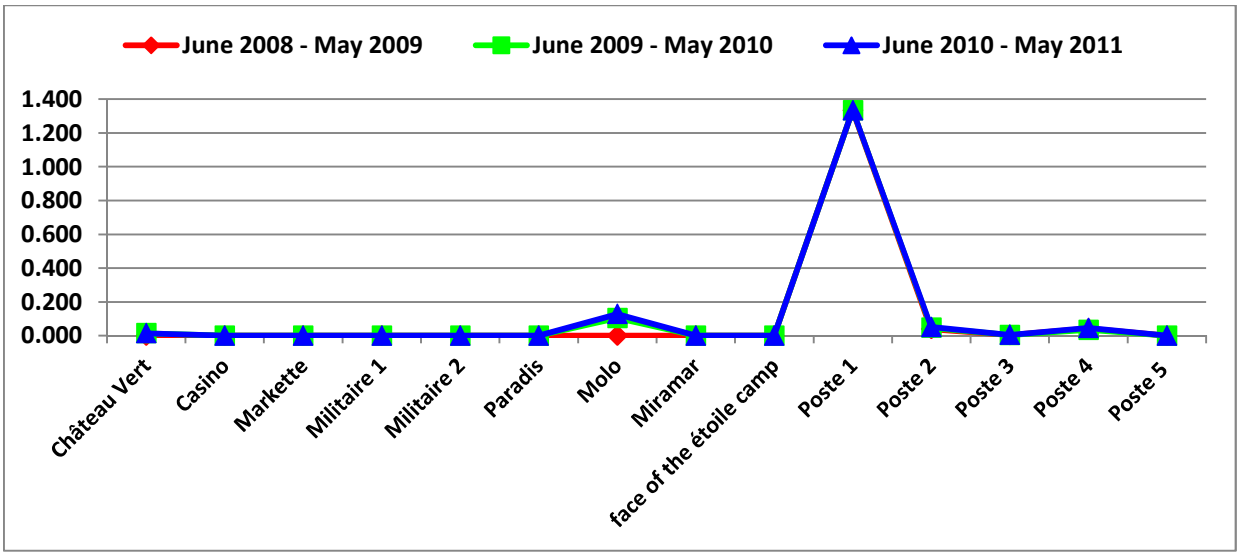

Figure 6. Variation of the index of bourgeois of the stations

The results of univariate analysis of variance ANOVA, applied between the assembly station 8 of bacteriological and physico-chemical characteristics, have average fair showing significant differences for the CF, and highly significant for CT and SF and very highly significant for temperature, electrical conductivity and dissolved O_2, and the total absence of significant differences in each variable salinity and pH. And that applied between months show

the existence of very highly significant differences between the 36 months for all physico-chemical variables and highly significant for CF and no significant differences for CT and SF.

CONCLUSION

This monitoring program spread over 3 years has allowed to determine the real and potential impact of bacterial pollution in the waters of the Gulf of Skikda bathing. The year 2008 saw major fecal germs contamination rates. The calculation of the index of Bourgeois demonstrates that the study area has been exposed to essentially animal pollution. About the Gulf of Skikda bathing water, they remain in the Algerian standards for all of the germs sought with a predominance of total coliforms: 80,87%, followed by the fecal Streptococcus: 18.88% and finally the fecal coliform: 0.25%. All physicochemical and bacteriological results obtained remain consistent with the Algerian standards and those of the OMS/UNEP (1983) relating to recreational waters [2]. The main beaches of the wilaya of Skikda are regarded as being of good quality with the exception of 2 beaches of green Castle and the 3 position which remain acceptable for bathing with temporary variations in the bacteriological quality and which must be the continuous control and monitoring.

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