Correlations: T; pH; S; C; CT; CF; EC; SF

	T	pH	S	C	CT	CF	EC
pH	-0,113						
	0,199						
S	0,467	0,181					
	0,000	0,040					
C	0,316	-0,125	0,473				
	0,000	0,158	0,000				
CT	0,112	-0,248	0,046	0,165			
	0,205	0,004	0,602	0,061			
CTT	0,034	-0,043	0,113	0,063	0,698		
	0,700	0,628	0,201	0,474	0,000		
EC	0,012	0,051	0,090	0,025	0,613	0,970	
	0,892	0,565	0,308	0,780	0,000	0,000	
SF	-0,004	0,082	0,167	0,112	0,262	0,343	0,351
	0,964	0,353	0,058	0,205	0,003	0,000	0,000

Cell Contents: Pearson correlation
P-Value

General Linear Model: T; pH; S; C; CT; CTT; EC; SF versus année; Stations

Factor	Type	Levels	Values
année	fixed	2	1; 2
Stations(année)	fixed	20	B; CV; J; M; p; P2; P3; P5; P6; P7; B; CV; J; M; p; P2; P3; P5; P6; P7

Analysis of Variance for T, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
année	1	67,104	67,104	67,104	7,52	0,007**
Stations(année)	18	13,033	13,033	0,724	0,08	1,000 ns
Error	110	981,435	981,435	8,922		
Total	129	1061,572				

S = 2,98700   R-Sq = 7,55%   R-Sq(adj) = 0,00%

Analysis of Variance for pH, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
année	1	3,36477	3,36477	3,36477	41,76	0,000***
Stations(année)	18	0,52174	0,52174	0,02899	0,36	0,992 ns
Error	110	8,86231	8,86231	0,08057		
Total	129	12,74882				

S = 0,283842   R-Sq = 30,49%   R-Sq(adj) = 18,48%

Analysis of Variance for S, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
année	1	2,8755	2,8755	2,8755	3,80	0,054 ns
Stations(année)	18	10,3073	10,3073	0,5726	0,76	0,744 ns
Error	110	83,1745	83,1745	0,7561		
Total	129	96,3573				

S = 0,869559   R-Sq = 13,68%   R-Sq(adj) = 0,00%

Analysis of Variance for C, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
année	1	0,1715	0,1715	0,1715	0,39	0,534 ns
Stations(année)	18	5,1770	5,1770	0,2876	0,65	0,848 ns
Error	110	48,3614	48,3614	0,4396		
Total	129	53,7099				

S = 0,663061   R-Sq = 9,96%   R-Sq(adj) = 0,00%

Analysis of Variance for CT, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
année	1	18320258	18320258	18320258	2,19	0,142 ns
Stations(année)	18	316189609	316189609	17566089	2,10	0,010**
Error	110	921027097	921027097	8372974		
Total	129	1255536964				

S = 2893,61   R-Sq = 26,64%   R-Sq(adj) = 13,97%

Analysis of Variance for CTT, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
année	1	3506235	3506235	3506235	1,03	0,313 ns
Stations(année)	18	47524480	47524480	2640249	0,77	0,726 ns
Error	110	375162701	375162701	3410570		
Total	129	426193416				

S = 1846,77   R-Sq = 11,97%   R-Sq(adj) = 0,00%

Analysis of Variance for EC, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
année	1	6420755	6420755	6420755	1,98	0,162 ns
Stations(année)	18	42153638	42153638	2341869	0,72	0,782 ns
Error	110	356467897	356467897	3240617		
Total	129	405042290				

S = 1800,17   R-Sq = 11,99%   R-Sq(adj) = 0,00%

Analysis of Variance for SF, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
année	1	34761359	34761359	34761359	6,16	0,015*
Stations(année)	18	128111367	128111367	7117298	1,26	0,228 ns
Error	110	620879654	620879654	5644360		
Total	129	783752381				

S = 2375,79   R-Sq = 20,78%   R-Sq(adj) = 7,10%

Grouping Information Using Tukey Method and 95,0% Confidence for T

année	Stations	N	Mean	Grouping
1	P3	6	24,7	A
1	P7	6	24,6	A
1	P6	6	24,4	A
1	P2	6	24,4	A
1	P5	6	24,3	A
1	p	6	23,7	A
1	M	6	23,7	A
1	J	6	23,7	A
1	CV	6	23,6	A
1	B	6	23,6	A
2	P5	7	22,9	A
2	p	7	22,9	A
2	P3	7	22,7	A
2	B	7	22,7	A
2	P7	7	22,6	A
2	P6	7	22,6	A
2	P2	7	22,6	A
2	J	7	22,6	A
2	CV	7	22,3	A
2	M	7	22,2	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for T

année	N	Mean	Grouping
1	60	24,1	A
2	70	22,6	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for pH

année	Stations	N	Mean	Grouping
2	P5	7	8,3	A
2	P2	7	8,2	A
2	P6	7	8,2	A
2	P3	7	8,2	A
2	P7	7	8,2	A
2	M	7	8,2	A
2	p	7	8,2	A

2	CV	7	8,2	A
2	J	7	8,2	A
2	B	7	8,1	A
1	P2	6	8,0	A
1	P3	6	7,9	A
1	B	6	7,9	A
1	p	6	7,9	A
1	P5	6	7,9	A
1	P6	6	7,9	A
1	M	6	7,9	A
1	P7	6	7,9	A
1	J	6	7,7	A
1	CV	6	7,7	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for pH

année	N	Mean	Grouping
2	70	8,2	A
1	60	7,9	B

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for S

année	Stations	N	Mean	Grouping
1	M	6	37,2	A
2	p	7	37,1	A
2	M	7	37,0	A
2	B	7	36,9	A
2	CV	7	36,8	A
2	P5	7	36,8	A
2	P2	7	36,7	A
1	P7	6	36,7	A
2	P6	7	36,7	A
1	P3	6	36,6	A
2	J	7	36,6	A
2	P7	7	36,6	A
1	P6	6	36,6	A
1	CV	6	36,6	A
2	P3	7	36,5	A
1	P5	6	36,4	A
1	P2	6	36,4	A
1	p	6	36,4	A
1	B	6	36,4	A
1	J	6	35,6	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for S

année	N	Mean	Grouping
2	70	36,8	A
1	60	36,5	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for C

année	Stations	N	Mean	Grouping
1	B	6	56,4	A
1	M	6	56,3	A
2	M	7	56,2	A
2	CV	7	56,2	A
1	P6	6	56,2	A
2	B	7	56,1	A
2	p	7	56,1	A
1	P2	6	56,1	A
1	J	6	56,0	A
1	P5	6	56,0	A
2	P3	7	55,9	A
1	CV	6	55,9	A
2	P2	7	55,9	A
2	P6	7	55,9	A
1	P7	6	55,9	A
1	p	6	55,8	A
2	J	7	55,8	A
2	P5	7	55,7	A
2	P7	7	55,7	A
1	P3	6	55,7	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for C

année	N	Mean	Grouping
1	60	56,0	A
2	70	56,0	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for CT

année	Stations	N	Mean	Grouping
1	CV	6	5731,7	A
1	J	6	5625,0	A
1	M	6	2287,8	A
2	P5	7	2096,1	A
2	B	7	2048,4	A
2	J	7	1768,3	A
1	P3	6	1549,0	A
2	p	7	693,0	A
2	P7	7	675,1	A
2	M	7	513,6	A
1	P5	6	410,0	A
2	P2	7	400,6	A
1	P2	6	303,0	A
2	CV	7	268,6	A
2	P3	7	207,3	A
1	P6	6	174,8	A
1	B	6	92,3	A
1	p	6	30,2	A
2	P6	7	18,9	A
1	P7	6	16,3	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for CT

année	N	Mean	Grouping
1	60	1622,0	A
2	70	869,0	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for CTT

année	Stations	N	Mean	Grouping
2	P5	7	2086,9	A
2	B	7	2009,9	A
1	M	6	888,8	A
2	J	7	777,7	A
1	CV	6	745,0	A
1	J	6	370,0	A
2	P2	7	232,3	A
2	M	7	153,1	A
2	CV	7	110,1	A
2	P3	7	90,1	A
1	P2	6	84,2	A
1	P5	6	76,3	A
2	p	7	73,7	A
1	P6	6	72,7	A
2	P7	7	68,4	A
1	P3	6	31,0	A
1	B	6	22,2	A
1	p	6	16,2	A
1	P7	6	8,3	A
2	P6	7	6,7	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for CTT

année	N	Mean	Grouping
2	70	560,9	A
1	60	231,5	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for EC

année	Stations	N	Mean	Grouping
2	P5	7	2051,1	A
2	B	7	2009,9	A
2	J	7	738,0	A
1	J	6	370,0	A
1	CV	6	351,7	A
2	P2	7	232,3	A
2	M	7	153,1	A

1	M	6	147,2	A
2	CV	7	108,3	A
2	P3	7	87,7	A
1	P2	6	84,2	A
2	P7	7	66,9	A
2	p	7	51,1	A
1	P3	6	30,2	A
1	P6	6	25,8	A
1	B	6	22,2	A
1	P7	6	7,3	A
2	P6	7	5,6	A
1	P5	6	5,3	A
1	p	6	2,2	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for EC

année	N	Mean	Grouping
2	70	550,4	A
1	60	104,6	A

Means that do not share a letter are significantly different.

<u>Grouping Information Using Tukey Method and 95,0% Confidence for SF</u>

année	Stations	N	Mean	Grouping
2	B	7	4093,7	A
2	J	7	3074,3	A
2	P3	7	2305,1	A
2	P6	7	1593,0	A
1	J	6	1496,7	A
1	CV	6	1119,7	A
2	P2	7	988,0	A
2	P5	7	678,1	A
2	CV	7	638,6	A
1	M	6	561,2	A
2	M	7	497,0	A
1	B	6	454,3	A
2	P7	7	213,3	A
2	p	7	100,1	A
1	P5	6	67,2	A
1	P3	6	45,5	A
1	P2	6	34,5	A
1	P6	6	14,5	A
1	P7	6	11,2	A
1	p	6	3,8	A

Means that do not share a letter are significantly different.

Grouping Information Using Tukey Method and 95,0% Confidence for SF

année	N	Mean	Grouping
2	70	1418,1	A
1	60	380,9	B

Means that do not share a letter are significantly different.

<u>Annexe 11</u> : <u>Composition des différents milieux de culture utilisés</u> :

- B.C.P. L : (bouillon lactosé au pourpre de bromocrésol) permet de la recherche et le dénombrement des coliformes, par la fermentation du lactose et la production de gaz. On distingue :

- <u>le BCPL double concentration</u> :

Composants	Quantité
Peptone ou tryptone	10 g / l
Extrait de viande de boeuf	6 g / l
Lactose	10 g / l
Pourpre de bromocrésol	0,05 g / l
Eau distillée	1000 ml

- <u>le BCPL simple concentration</u> :

Composants	Quantité
Peptone ou tryptone	5 g / l
Extrait de viande de boeuf	3 g / l
Lactose	5 g / l
Pourpre de bromocrésol	0,025 g / l
Eau distillée	1000 ml

- Shubert: (milieu indole mannitol) utilisé pour déterminer la présence des coliformes themotolérants (test de confirmation).

Composants	Quantité
Tryptophane	0,2 g
Acide glutamique	0,2 g
Sulfate de magnésium	0,7 g
Sulfate d'ammonium	0,4 g
Citrate de sodium	0,5 g
Chlorure de sodium	2 g
Peptone	10 g

Mannitol	7, 5 g
Eau distillée	500 ml
Tampon phosphate (solution tampon (pH 7,6) : mélanger 435 ml d'une solution de Na_2HPO_4 à 9,47 $g.L^{-1}$ et 65 ml d'une solution de KH_2PO4 à 9,07 $g.L^{-1}$)	500ml

- **Rothe :** (Bouillon Glucose l'acide de sodium) utilisé pour la recherche et le dénombrement des streptocoques fécaux. On distingue :

- Rothe double concentration :

Composants	**Quantité**
Tryptone ou peptone	40 g
Glucose	10 g
Chlorure de sodium (NaCl)	10 g
Azothydrate de sodium	0,4 g
Monohydrogénophosphate de potassium (HK_2PO_4)	5,4 g
Dihydrogénophosphate de potassium (H_2KPO_4)	5,4 g
Eau distillée	1000 ml

- Rothe simple concentration :

Composants	**Quantité**
Tryptone ou peptone	20 g
Glucose	5 g
Chlorure de sodium (NaCl)	5 g
Azothydrate de sodium	0,2 g
Monohydrogénophosphate de potassium (HK_2PO_4)	2,7 g
Dihydrogénophosphate de potassium (H_2KPO_4)	2,7 g

Eau distillée	1000 ml

- **Eva Litsky:**

Composants	**Quantité**
Peptone ou tryptone	20 g
Glucose	5 g
Chlorure de sodium (NaCl)	5 g
Monohydrogénophosphate de potassium(HK_2PO_4)	2,7 g
Dihydrogénophosphate de potassium (H_2KPO_4)	2,7 g
Azoture de sodium (NaN_3)	0,3 g
Solution d'éthyl violet	0,0005 g (5 ml)
Eau distillée	1000 ml

- **Réactif de Kovacs** (pour la mise en évidence de l'indol) **:**

Composants	**Quantité**
Paradiméthyl aminobenzaldéhyde (diméthylamino-4 benzaldéhyde)	5 g
Alcool amylique (pentanol-1)	75 ml
Acide chlorhydrique pur	25 ml

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Quality of swimming waters in the Gulf of Skikda (Algeria)

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ABSTRACT The purpose of this study is to determine the bacteriological and physico-chemical quality of swimming waters in the region of Skikda (Algeria), a popular tourist area known for its many beaches, through the water analysis of ten sites. This monitoring program was carried out for a period of five months.

KEY WORDS swimming waters; bacteriological pollution, physico-chemical parameters; Gulf of Skikda.

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INTRODUCTION

The sea is an essential element of our life, source of food and of leisures; it represents, in most Mediterranean countries, a significant part in the economy, thanks to tourism, it concentrates in fact over 30% of international tourism (UNEP/MAP, 2012); its quality has therefore a major importance. These last years, strong urbanization, tourism and democratization of aquatic activities involved an increase in frequentation of the Mediterranean coastline and therefore a degradation of the quality of coastal waters.

In this study, we will try to determine the microbiological and physico-chemical quality of the swimming waters of the Gulf of Skikda through the water analysis of a ten station thus covering the entire Gulf.

MATERIAL AND METHODS

The wilaya of Skikda is located in north-eastern Algeria bordering the Mediterranean Sea and has a coastline of over 140 km long. Our study area gathers two villages and extends over twenty kilometers, it includes, east beaches Filfila and Ben M'hidi about 15 Km and to the west, a road about 3 Km beaches (Fig. 1). In addition the Gulf of Skikda is a discharge point for many wadis: Wadi Safsaf the main one, flowing in the center of the Gulf, and two secondary wadis at Filfila.

The samples, transport and analysis of seawater samples were conducted according to guidelines for the monitoring of the quality of swimming waters. This monitoring program was carried out for a period of five months (December 2013–April 2013). The collected data were measured in each seawater sample taken per month per site. The analysis focuses on the quantification of faecal indicator bacteria (total coliforms, faecal and faecal streptococci) using the method of the enumeration in liquid medium by determining the most probable number (MPN); as well as determining certain physicochemical parameters (electrical conductivity, pH, dissolved oxygen, ...).

The health status of swimming water is assessed based on the results obtained and compared to thresholds, quality bacteriological and physico-chemical criteria present in the Executive Decree No. 93-164.

Moreover, in order to compare the averages of the different physico-chemical parameters measured between the ten sites, we used the test of the analysis of variance in a criterion of classification (ANOVA), fixed pattern.

RESULTS AND DISCUSSION

Regarding the average results recorded for the various physico-chemical parameters, we note that those are in adequacy with the quality standards required for swimming waters by the standards in force (Table 1). The temporal variation of the concentrations of different germs sought shows that they fluctuate in the same way showing their dominance during the month of December (Fig. 2). This can be justified by climatic conditions recorded during this month which resulted in the discharge of rainwater directly into the sea without treatments, the high flows of urban waste and wadis, the agitation of the water, etc. (Mazières, 1963).

Moreover, presence of enteric bacteria in the sea water can be justified by several phenomena and is conditioned by a number of specific parameters including:

- Physical factors: temperature, absorption / adsorption, dispersion, dilution, sedimentation, light (bactericidal radiation at shallow depths only) (see Carlucci & Pramer, 1959; Brisou, 1968; UNEP / WHO, 1983; Pommepuy et al., 1991; Gourmelon, 1995);
- Chemical factors: salinity (selection factor), and dietary deficiencies in vitamins, fasting, dissolved oxygen (Carlucci & Pramer, 1959; Brisou, 1968);
- Biological factors: microphage plankton or adsorbent, benthos and nekton (macrophage-plankton), vital competition, bacteriophages (Brisou, 1968; Oger et al., 1983; Gourmelon., 1995).

All these factors act together; either simultaneously or in successive steps in time and in space, to reduce the number of bacteria or eliminate them.

The spatial variation of the concentrations of different germs sought allows us to see that as, a whole, the average results recorded are in adequacy with the quality standards for swimming waters except for the fourth site where registered rates are significantly higher than the limit values required for fecal coliforms and fecal streptococci (Fig. 3). The results obtained at the fourth site, namely the “Beach la jetée" shows a fecal contamination and,

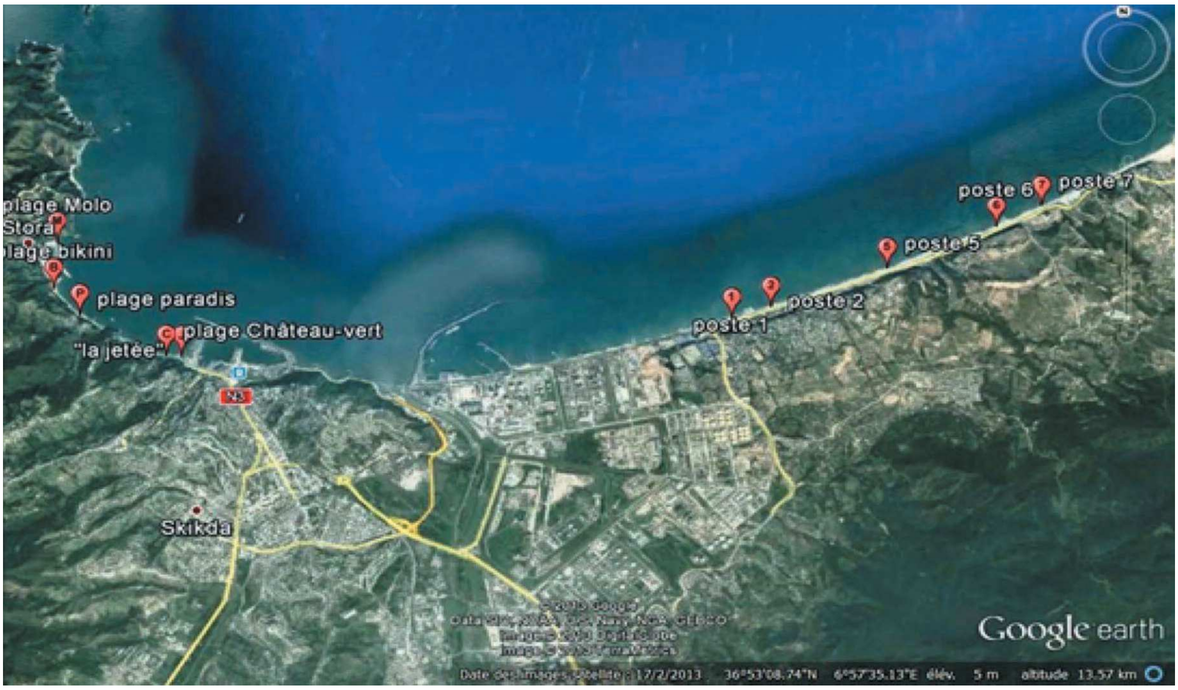

Figure 1. Location of the study area and sampling sites, Gulf of Skikda, Algeria.

therefore, its poor bacteriological quality. The presence of an urban emissary explains these results and justifies its permanent closure for swimming.

Moreover, analysis of total coliforms does not allow to assess the quality of water because a great heterogeneity of species is grouped under this term. In fact, some of them are certainly of fecal origin and may reflect a fecal pollution of water, but others are found naturally in the soil or vegetation (Rodier et al., 2005); Today, only the detection of fecal coliforms, specifically *Escherichia coli* and intestinal enterococci, in water must seriously let suspect fecal contamination, since they are the most reliable enteric pathogens, and therefore the best way to detect recent fecal contaminations (Payment & Hartmann, 1998; Scientific Group on Water, 2003).

The results of the univariate analysis of variance (ANOVA) for the five physicochemical variables measured, allow us to note the lack of significant differences between the waters of the ten sites studied (Table 2), which confirms our previous observations as to the equivalence of swimming waters sites studied from the physico-chemical point of view.

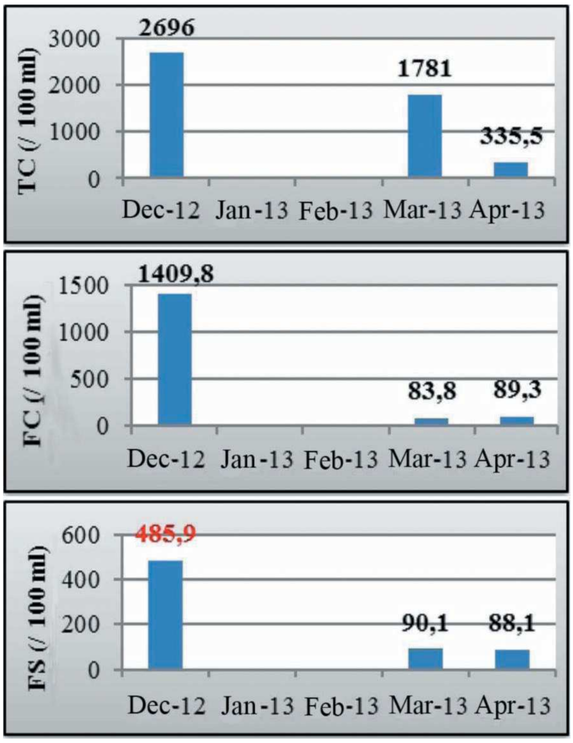

Figure 2. Temporal variation of germs recorded during the study period.

	T (°C)	pH	Salinity	Conductivity (mS/cm)	Saturation dissolved O_2 (%)
Site 1 «château-vert »	13.82	7.62	36.40	54.72	106.68
Site 2 «paradis »	13.88	7,7	36.42	54.74	106.62
Site 3 « molo »	14.24	7.60	36.46	54.70	104.88
Site 4 «la jetée »	13.76	7.61	36.04	54.22	98.18
Site 5 «poste 1 »	14.76	7.72	36.24	54.82	106.90
Site 6 «bikini »	13.78	7.62	36.32	54.80	104.62
Site 7 «poste 2 »	14.66	7.75	36.24	54.92	108.08
Site 8 «poste 5 »	14.58	7.74	36.22	54.84	107.90
Site 9 «poste 6 »	14.84	7.67	36.16	54.94	108.88
Site 10 «poste 7 »	14.78	7.67	36.34	54.96	108.84

Table 1. Average results of physico-chemical parameters measured.

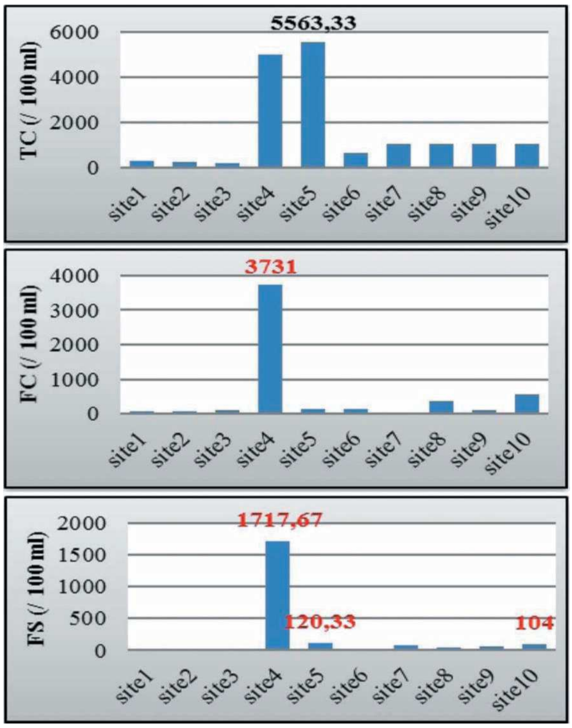

Figure 3. Spatial variation of germs recorded during the study period.

Variables	Sources of variation	ddl	SCE	CM	F_{obs}
T (°C)	Sites	9	9.55	1.062	0.096 ns
pH	Sites	9	0.142	0.016	0.108 ns
S (‰)	Sites	9	0.751	0.083	1.203 ns
Conductivity (mS/cm)	Sites	9	2.032	0.226	0.236 ns
O_2 (%)	Sites	9	450.074	50.008	1.285 ns

Table 2. Results of the analysis of variance (ANOVA) of fixed patterns in comparisons between the sites; for each of the five physicochemical variables, average values were considered. Abbreviations: ddl = degrees of freedom; SCE = sum of squared deviations; CM = mean square; Fobs = F value Fischer.

CONCLUSION

So, in the light of the results of physico-chemical analysis, the swimming waters of the different study sites are good given the Algerian standards, since results are not above the normal values for swimming waters.

However when considering bacteriological analyses such waters show, depending on the months and the sites, although in the standards, a relatively high rate of coliforms and streptococci, thus allowing us to suggest the existence of a kind of pollution of various origins (mainly urban waste and stormwater runoff flowing into the sea without treatment), observed especially at site 4, but present at all other sites, even if less obvious.

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Evaluation of the quality of swimming water in the Gulf of Skikda (Algeria)

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Abstract

The aim of this study is to evaluate the bacteriological and physicochemical quality of the swimming waters of the Skikda region, a very touristic area known for its many beaches which are frequented during the summer period, through the water analysis of ten stations. Because the destination "sea" is far ahead of all the others (mountain, desert, museum, etc) in Algeria, where during the summer season, swimming is the most practiced recreational activity; the quality of swimming water is therefore an essential factor for the tourist development of coastal communities. This monitoring program focused on monitoring water quality during two summer seasons. The analyses concern the quantification of fecal contamination bacteria (total and thermo tolerant coliforms, *E. coli* and fecal streptococci), as well as the determination of certain physico-chemical parameters (electrical conductivity, pH, salinity, etc.). In view of the results, we can suppose the existence of a pollution having various origins at the levels of the different sites studied. In fact, for 9 out of 10 sites, we have average fecal streptococcal levels well above current standards (less than 100 FS/100 ml).

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Introduction

Water is a factor in the spread of many pathogenic and non-pathogenic micro-organisms, monitoring and control of the microbiological quality of swimming waters is an essential element in the preservation of public health; Although its importance may seem less important than that of feedwater; But also an important element of tourism development.

Euripides said "the sea cures all the evils of mortals"; However, strong urbanization, tourism and the democratization of aquatic activities have resulted in an increase in the number of visitors to the Mediterranean coast and thus a deterioration in the quality of coastal waters.

This study concerns the monitoring of the bacteriological and physicochemical quality of the swimming waters of the Gulf of Skikda through the analysis of the waters of a ten stations.

Materials and methods

Study area

The wilaya of Skikda is located in the north-east of Algeria bordering the Mediterranean Sea and has a coastaline of over 140 km long.

Our study area includes two municipalities and extends about twenty kilometers, it includes, to the east, the beaches of Filfila and Ben M'hidi about 15 km and to the West, a road of approximately 3 Km from beaches (Fig. 1).

Fig. 1. Location of the study area and sampling sites, Gulf of Skikda, Algeria.

In addition, the Gulf of Skikda is a point of discharge for many wadis : the main is wadi Safsaf which flows into the center of the gulf but there are also two secondary wadis at Filfila.

Sample Collection

Sampling, transport and analysis of seawater samples were carried out according with the guidelines for the monitoring of the quality of swimming waters.

This monitoring program was conducted during two summer seasons (April 2015-September 2016). The collected data were measured in each sample of seawater taken per month and per site.

The Experiments

The Analysis include quantification of fecal-indicator bacteria (total and the rmotolerant coliforms, *E. coli* and fecal streptococci) using the method of the enumeration in liquid medium by determining the most probable number (MPN); As well as on the determination of certain physico-chemical parameters (Electrical conductivity, pH, etc.).

The health status of swimming water is assessed based on the results obtained and compared with the threshold values for the quality of the bacteriological and physico-chemical criteria presented in Executive Decree No. 93-164. Moreover, in order to compare the averages of the different physicochemical parameters measured between the ten sites, we used the test of the analysis of variance in a criterion of classification (ANOVA), fixed pattern.

Results and discussion

Physicochemical parameters

As regards the average results recorded for the various physicochemical parameters, we find that these are in adequacy with the quality standards required for swimming waters by the standards in force (Table 1).

Table 1. Average results of physico-chemical parameters measured.

parameters / Site	T (°C)	pH	Salinity	Conductivity (mS/cm)
Site 1 «la jetée »	23,108	7,971	36,161	55,915
Site 2 «château-vert »	22,931	7,966	36,708	56,061
Site 3 «paradis »	23,269	8,086	36,731	55,985
Site 4 «bikini»	23,069	8,052	36,638	56,277
Site 5 «molo»	22,923	8,077	37,1	56,269
Site 6 «poste 2 »	23,446	8,117	36,592	56,008
Site 7 «poste 3 »	23,615	8,094	36,592	55,823
Site 8 «poste 5 »	23,561	8,108	36,608	55,869
Site 9 «poste 6 »	23,461	8,088	36,631	56,015
Site 10 «poste 7 »	23,538	8,079	36,661	55,785

Table 2. Results of the analysis of variance (ANOVA) of fixed patterns in comparisons between the sites; for each variables, average values were considered. Abbreviations: ddl = degrees of freedom; SCE = sum of squared deviations; CM = mean square; Fobs = F value Fischer.

Variables	Sources of variation	Ddl	SCE	CM	F_{obs}
T (°C)	Sites	9	8,345	0,927	0,1056 ns
pH	Sites	9	0,33	0,04	0,354 ns
S (‰)	Sites	9	5,973	0,664	0,886 ns
Conductivity (mS/cm)	Sites	9	3,32	0,369	0,885 ns
CT (/100ml)	Sites	9	$1,504.10^{8}$	$1,67.10^{7}$	1,814 ns
CF (/100ml)	Sites	9	$2,197.10^{7}$	$2,44.10^{6}$	0,72 ns
E.C (/100ml)	Sites	9	$2,2.10^{7}$	$2,44.10^{6}$	0,76 ns
SF (/100ml)	Sites	9	$7,56.10^{7}$	$8,4.10^{6}$	1,424 ns

Bacteriological analyses

The temporal variation of the concentrations of the different germs indicates that they fluctuate in the same way, showing their predominance during the months of August 2015 and September 2016 for total and thermotolerants coliforms; and during July 2015 and September 2016 for *E. coli* and fecal streptococci (Fig. 2).

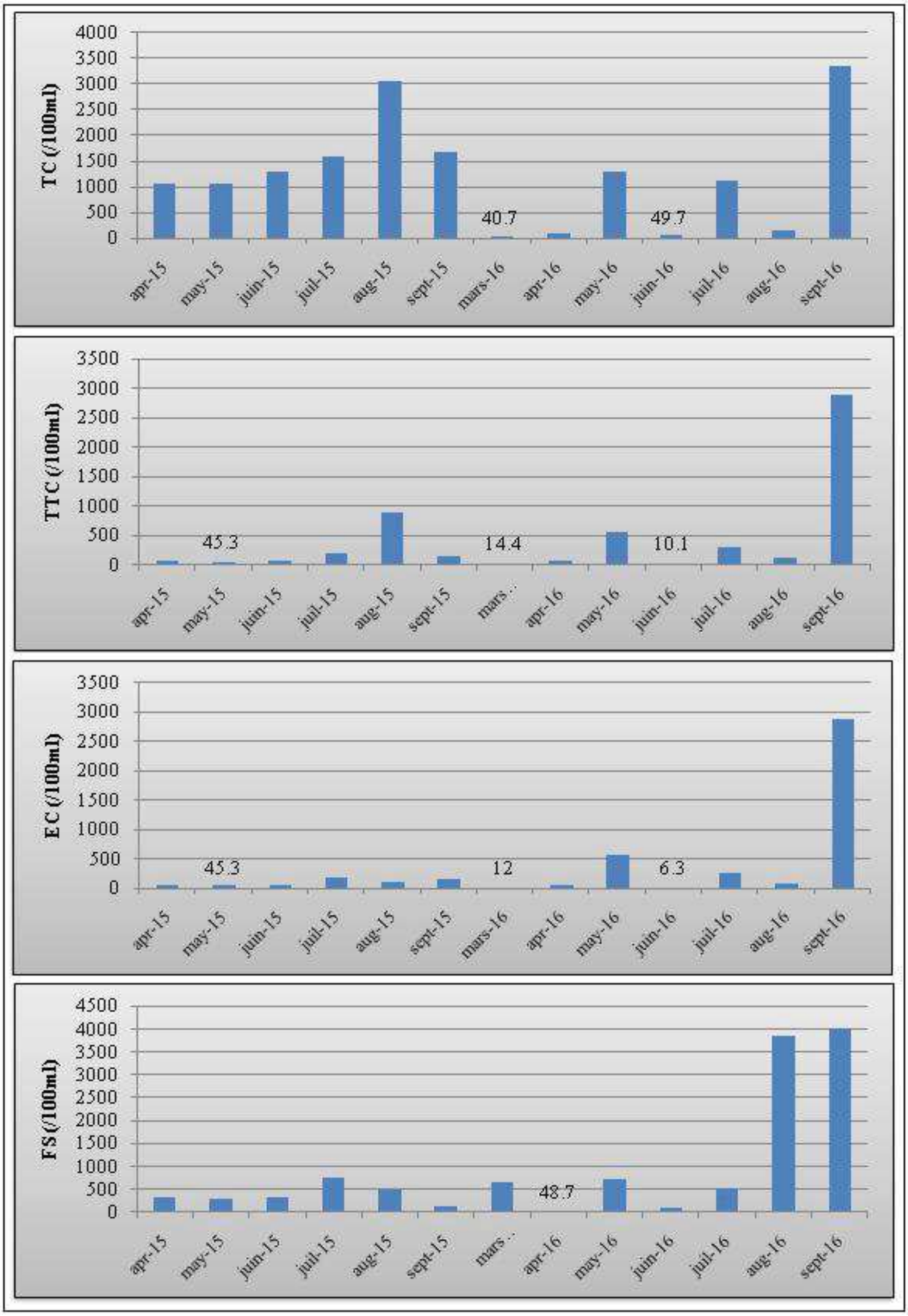

Fig. 2. Temporal variation of germs recorded during the study period.

TC: total coliforms; TTC: thermotolerant coliforms; EC: *E. coli*; FS: fecal streptococci.

This may be justified by the frequentation rates of beaches that were low due to fasting (Ramadan); as well as the climatic conditions recorded during the month of September, which have resulted in an increase in beach frequencies and the discharge of rainwater directly into the sea without treatment, high flows from urban wastewater and wadis, agitation of water etc. (Mazières, 1963).

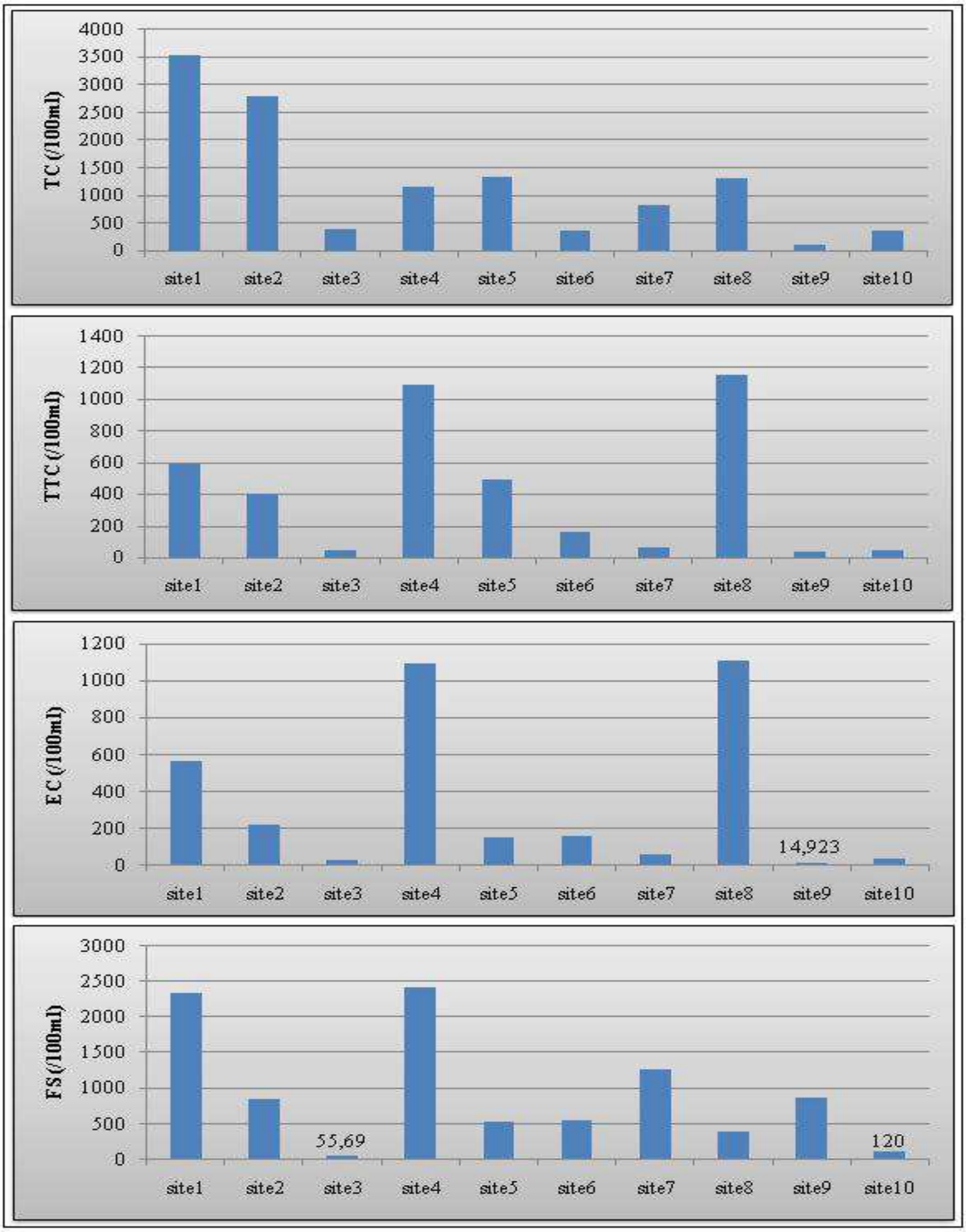

Fig. 3. Spatial variation of germs recorded during the study period.

TC: total coliforms; TTC: thermotolerant coliforms; EC: *E. coli*; FS: fecal streptococci.

Moreover, this fluctuation can be justified by several phenomena. Indeed, the fate of enteric bacteria in seawater is conditioned by a number of parameters specific to the environment, as physical factors (temperature, absorption/adsorption, dispersion, dilution, sedimentation, light (bactericidal radiation at shallow depths only)) (Carlucci and Pramer, 1959; Brisou, 1968; UNEP / WHO, 1983; Pommepuy *et al.*, 1991, Gourmelon, 1995); or chemical factors (salinity (selection factor), dietary deficiencies in vitamins, fasting, dissolved oxygen, etc) (Carlucci and Pramer, 1959; Brisou, 1968); and biological factors (microphagic plankton or adsorbent, benthos and nekton (macrophage-plankon), vital competition, bacteriophages, etc). (Brisou, 1968) and Oger *et al.*, 1983, Gourmelon, 1995).

All of these factors act together; either simultaneously or in successive steps in time and space, in order to reduce the number of bacteria or even eliminate them.

The spatial variation of the concentrations of the different germs sought allows us to observe that, overall, the average results in total coliforms and thermotolerants recorded are in adequacy with the quality standards required for swimming waters. However, analysis of total coliforms only allows to assess the quality of water only moderately; it is only indicative because of the great heterogeneity of species grouped under this term, some are of fecal origin and may reflect fecal pollution of water, but others are naturally found in soil or vegetation. (Rodier, 2005); Nowadays, only the detection of thermotolerant coliforms and specifically *E. coli* and intestinal enterococci in water must seriously let suspect fecal contamination, since these are considered as the most reliable indicators of enteropathogenic agents, and therefore the best way to detect recent fecal contamination for E. coli and old for intestinal enterococci. (Payment and Hartemann, 1998; Scientific Panel on Water, 2003).

For the 4th and 8th sites (beaches "bikini" and "poste 5"), the recorded rates are higher than the limit values for the average concentrations of *E. coli*; moreover, we can note that the average concentrations of fecal streptococci are all above the norms recommended by the Algerian legislation (except for site 3, "paradis beach") (Fig. 3). The results obtained show an old fecal contamination of the water, and therefore a poor bacteriological quality.

ANOVA variance

The results of the analysis of the univariate ANOVA variance for the four measured physico-chemical variables allow us to note the absence of significant differences between the waters of the ten sites studied (Table 2). The same is true for bacteriological parameters.

This confirms our previous observations on the equivalence of the swimming waters of the different sites studied.

Conclusion

Thus, in view of the results of physicochemical analyses, the swimming waters of the different sites studied are good given the Algerian standards, the results are not above the normal values for swimming waters. However, when we consider the bacteriological analyses, these waters show results, depending on the months and the sites; although in standards, a relatively high coliform and streptococcal levels; allowing us to suggest the existence of a kind of pollution, of various origins (mainly urban waste, stormwater runoff flowing into the sea without treatments), present at all sites more or less obvious.

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