Environmental study of the role of anthropogenic factors on the possible pollution of coastal marine waters in Dakhla Bay – Morocco

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Abstract— *The sites used for breeding and the beaches are ranked in descending order of health in 4 categories A, B, C and D according to the estimate of the microbiological quality and evaluation of the chemical contamination (circular 15.08.12 d 'August 2012). After classification, the target areas are subject to regular health surveillance, intended to verify the durability of the characteristics that have based their classification and to detect possible episodes of contamination. This monitoring covers the measurement of microbiological, chemical (heavy metal) and marine biotoxin parameters in bivalve molluscs, as well as phytoplankton pests in seawater.*

The Main objective of the present survey is to make a diagnosis of the state of health of the principal beaches of the region of Dakhla Oued Eddahaba bay in years 2015, 2016 and 2017. Our sampling focused on 4 beaches: Foum Lbouir, El Moussafir, Lakeira, and Tourist Area. Bacteriological analyzes were conducted to identify the microorganisms that are indicative of faecal pollution including faecal coliforms, faecal streptococci and Escherichia coli and their enumeration by the filter membrane method on nutrient media Tergitol7 Agar, Litsky, Slanetz & Bartley.

In addition to microbiological monitoring of seawaters, the air temperature was measured "in situ" using a mercury thermometer, the temperature of the water using a pH meter, the tide (high or low) and finally the estimate of the number of bathers.

*The Main results obtained made it possible to classify the four beaches in 3 categories according to the Moroccan standard for monitoring bathing water quality NM 03.7.200. The beaches of the Al Moussafir and Tourist PK25 are classified **A**. The beaches of Foum Lebouir with medium quality waters is classified **A** or **B**. Only the beach of Lakheira is very polluted and classified in category **C**.*

Keywords— Coast, Beaches, Swimming, Pollution, Microbiology, Coliforms, Streptococci, Dakhla, Morocco.

I. INTRODUCTION

The Moroccan coastline is a diverse, fragile area and today is very much threatened by profound urban and tourist pollution. With a coastline of approximately 3500 km, developing on two Atlantic and Mediterranean maritime facades, the Moroccan coastline occupies a privileged place at the level of the entire coastline of the African continent. The wealth, associated with the strategic space that represents the littoral, made of this last one a major space of development of the country in terms of urbanization, industrial zones and tourist equipments.

The Moroccan coastline is obviously a heritage of great importance for the country. It represents a Mediterranean facade stretching about 460 km from Tangier to Saidia and an Atlantic facade of 2500 km from Tangier to Lagouira.

It is a strategic area with a wide variety of natural and biological resources, including beaches, dunes, lagoons and wetlands. It is under increasing demographic pressure from urban agglomerations and the influence of various industrial, port and tourist activities.

Morocco has a strong tendency to urbanization estimated at 4.4% per year, which is accompanied by a phenomenon of coastalisation of the population. The expanding coastal agglomerations provide the bulk of urban growth with more than 60% of the total urban population of the country [1].

The coastline is also the location of most industrial units; more than 80% of industries are located near coastal areas. The industries are highly concentrated along the Kenitra-Safi axis and especially in the Casablanca agglomeration. This axis concentrates nearly 62% of industrial units and nearly 70% of industrial employment [1].

In addition, through the marine facilities located along the coast, transiting 98% of trade with the outside of this fact Moroccan water are experiencing intense shipping. Thus, hundreds of boats run daily along the Moroccan coast, including tankers and tankers that pose a permanent threat to marine pollution. Similarly, the important fisheries resources consist of more than 7137 animal species providing a fishing potential estimated at 1000 000 annual tons [2].

In recent years, tourism policy has made seaside a priority option and this by the development of certain areas such as Tangier and Agadir which concentrate 70% of the hotel capacity approved. The surge in domestic demand on the seaside has also led to the proliferation of second home projects and the occupation of the public domain, which has led to the emergence of a real lack of health infrastructure and consequently a negative impact on several beaches.

Moreover, the quality of the beaches has become over the years a criterion increasingly used by the general public to choose its holiday beaches. This led the authorities to ensure the protection of beaches against pollution by wastewater and to establish a classification of beaches according to their quality. In 2015, 373 declared beaches suitable for bathing in Morocco.

The Main objective of our current research is to make a diagnosis of bathing water safety through physicochemical and microbiological monitoring.

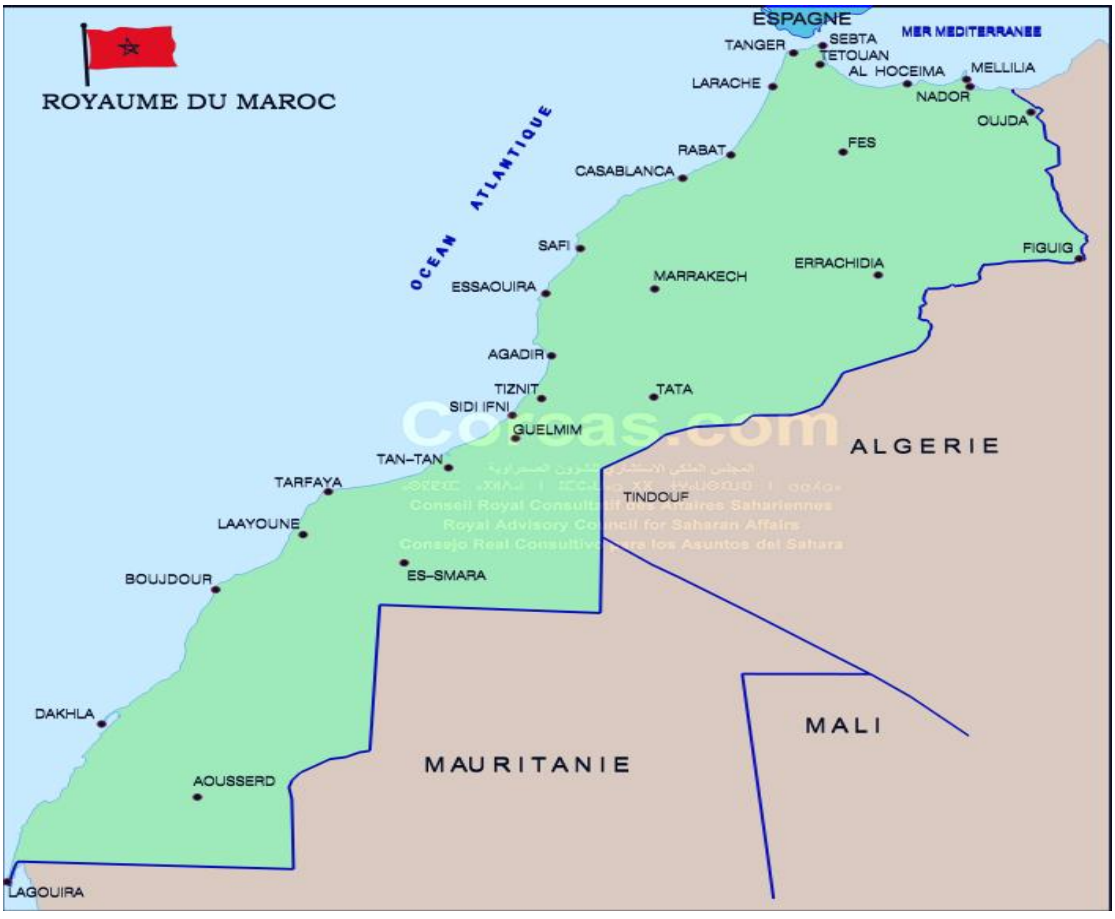

FIGURE 1: Moroccan map and geographical position of Dakhla-Oued Eddahab Bay

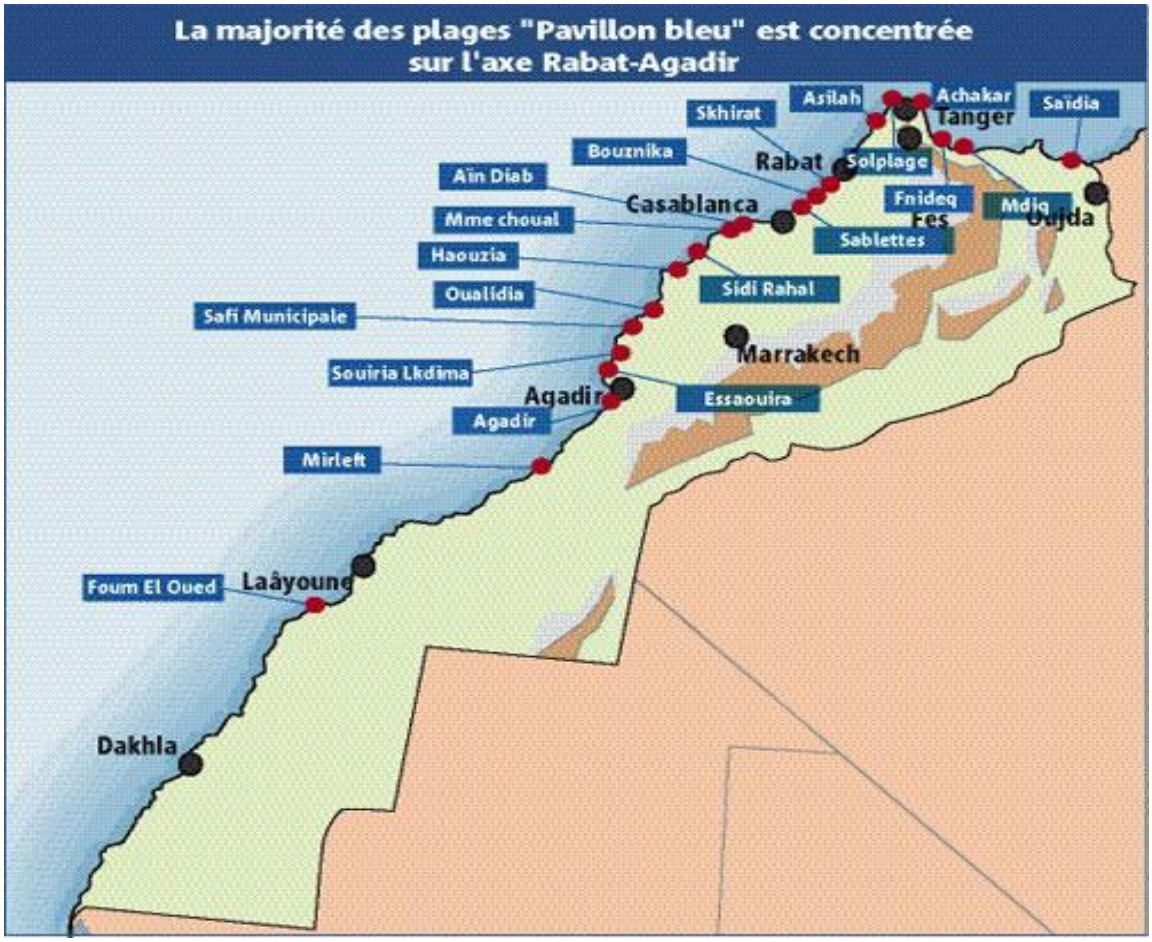

FIGURE 2: Moroccan Atlantic and Mediterranean beaches

II. MATERIAL AND METHOD

2.1 Study area

Our sampling focused on the 4 beaches of Dakhla bay: **Foum Lebouir**, **Al Moussafir**, **Tourist PK25**, and **Lakheira** Beaches (**Fig. 3**). The beaches that are the subject of our study are part of the Dakhla Oued Eddahab region which is the 12th region of Morocco. The Dakhla Oued Eddahab Region is divided into two provinces (divided into 4 circles and 13 communes including 2 urban). The region has 2 provinces: Oued Eddahab and Aousserd. The Ouad Eddahab province has an area of 76 948 km^2. With Dakhla as urban commune and 6 rural communes: El Argoub, Imlili, Bir Anzaran, Umm Dreyga, Gleibat El Foula, MIjik [**3**]. Aousserd province an area of 65,917 km^2. Lagouira is the urban municipality. 5 rural communes: Aousserd, Zug, Tichla, Aghouinite, Bir Gandouz [4].

The study area is located on the Atlantic coast, dominated by sandy beaches, rocky plateau without cliffs, small and medium cliffs, large dunes at more or less advanced stages of fixations by the flora of the sub floor. The tidal sway zone is essentially composed of very fine sand with shell debris.

Coastal marine currents are mainly induced by winds. The influence of the tide is very weak and the general current of the Canaries, south direction, is not perceptible near the coast. The study area is located in the city of Dakhla. The Dakhla Bay extends over a length of 37 km and an area of almost 400 km². The population of Wadi Eddahab in 2014 is about 126 057 inhabitants [3]. The population of Aousserd province in 2014 is 16 010 inhabitants [3].

The study area is subject to considerable urban pressure and is therefore influenced by the various urban, port and tourist activities. It receives inputs from the watersheds of Oued Eddahab region rivers and the continental alluvium they carry as well as the wastewater outfalls of coastal agglomerations and hotels.

FIGURE 3: Satellite view of the Oued Eddahab-Dakhla bay

2.1.1 Foum Labouir Beach

The beach of Foum Labouir is located on the bay of Oued Eddahab on the Atlantic coast of the urban district of Dakhla oriented NNE-SSW, about 8 km from the urban center (**Fig.4**). The beach of Foum Labouir is south of the park Foum Labouir. It is characterized by a clean concave bank with fine yellow-gray colored sands but is also the natural extension of several other natural sites such as the eco-forest park and the Tarouma farms, known for their ostrich breeding unit.

Foum Labouir is also a site to which fans and professionals of water sports converge, especially Surf and Kitsurf and where are organized several international competitions such as the Kitesurf World Cup.

This area has attracted many investors in the tourism sector and has seen the establishment of several hotel units such as the eco-lodge, West Point and other project in progress.

During each summer season, the beach "Foum Labouir" becomes a popular area for the people of Dakhla, who flock there en masse to enjoy the entertainment moments provided by its refreshing waters and golden sands.

Efforts are being made to increase the attractiveness of the city, improve its urban aesthetics, establish an architectural tradition that respects the environment, preserve the ecosystem of the bay and promote the tourist potential of the region.

In addition, the recent establishment of a new landfill, the implementation of liquid and solid sanitation projects, the development of the cornice and the coastal road, as well as green spaces have contributed to the attractiveness from the city and its beaches.

In addition to these achievements, other projects have been launched in recent months, including the development of public squares and green spaces as well as the renovation of the public lighting of the "Al Oualaa" avenue.

At the level of "Foum Labouir", the various measures taken in terms of environmental protection have made it possible to improve the cleanliness of the beach and the summering conditions and to create spaces dedicated to people with specific needs.

2.1.2 Beach of El Moussafir

The beach of Camping Moussafir is located on a creek on the right bank of the Wadi Eddahab bay. The beach is oriented NNE-SSW, about 7 km from the center of the city of Dakhla and the east side of the beach of Foum Labouir.

It is a beach labeled Blue Flag, clean with fine sands, color between pale yellow to white. And she is on the road that connects the city of Dakhla to Boujdour. The bathing area is characterized by calm waters and is equipped with umbrellas, and a pedestrian crossing at the seaside (**Fig.5**).

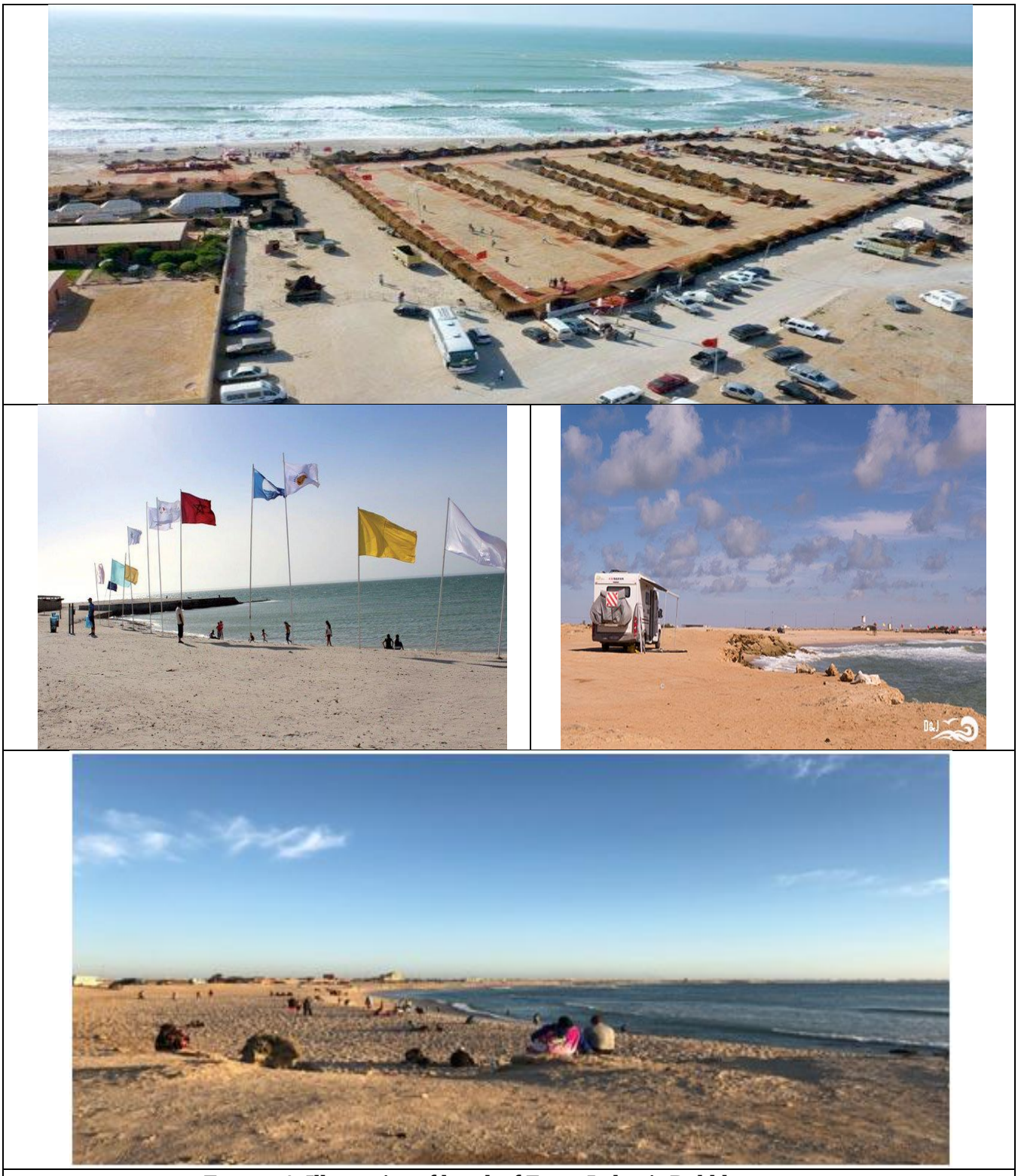

FIGURE 4: Illustration of beach of Foum Labouir Dakhla

FIGURE 5: Beach of El Moussafir (Dakhla)

2.1.3 Beach Lakheira

The LaKheira beach is a small beach in Dakhla. This beach is open on sea but receive é wastewaters collectors (**Fig.6**).

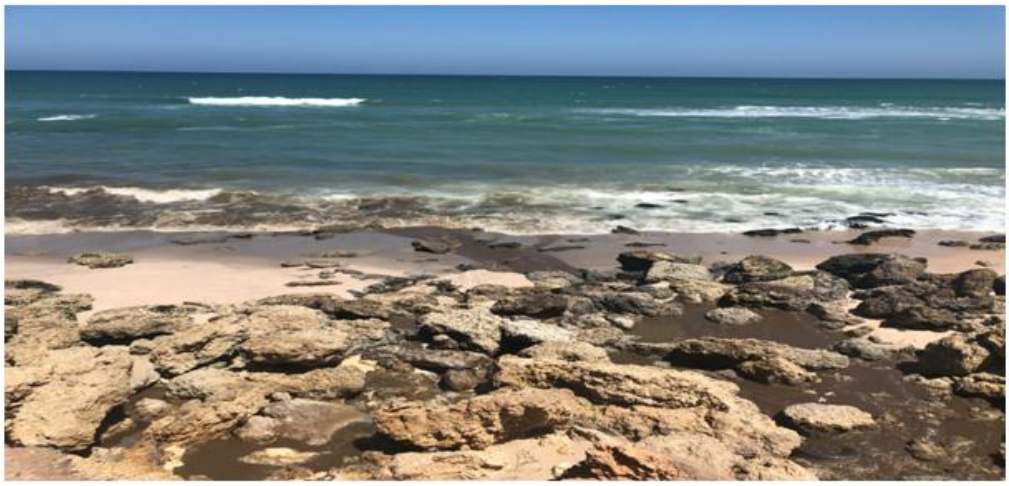

FIGURE 6: Playa Lakheira Dakhla.

2.1.4 Tourist PK25 Beach

The tourist area of Dakhla is located, northwest of the bay of Oued Eddahab. It is one of the best spot of the world to practice the Kite Surf. It is a clean beach, these sands have very fine granulometry, yellow color. It is located at 25 km from the city of Dakhla (**Fig.7**).

III. STUDY METHOD

3.1 Waters sampling

In sampling for a microbiological study, special precautions are needed to avoid contamination. For an optimal sampling one followed the Moroccan norm NM03.07.006. In our sampling we proceeded as follows (**Fig. 8**):

- sampling points are based on the extent of the beach in areas with the highest density of bathers;
- sampling at the level of the upper layer of the body of water at a depth of 30 cm;
- sampling frequency is two samples per month during the summer season and one per month for the rest of the year;
- the sampling time is fixed between 12h and 13h;
- the storage conditions of the samples designated for bacteriological analysis include storage in an insulated box at a temperature between 0 and 4 °C.

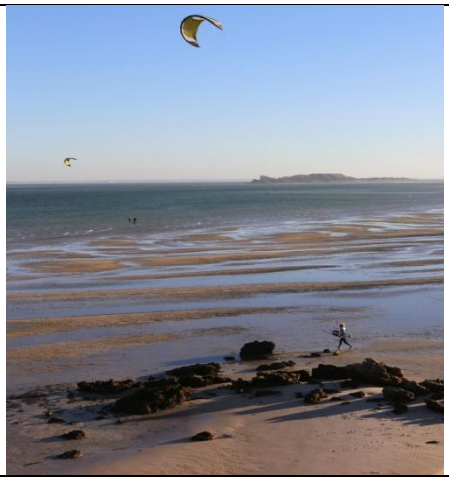

FIGURE 7: Illustration of the beach of Area Touristic PK25

In addition to the water sampling, the following parameters were measured "in situ":

+ temperature of the air using a mercury thermometer;

+ water temperature using a pH meter;

+ pH of the water using portable pH meter Hanna type Instrument;

+ tide level (high or low);

+ estimate of the bathers and swimming population.

FIGURE 8: Water sampling and microbial analysis

3.2 Microbiological analysis methods

For the prospecting of the biological quality of bathing waters, it is necessary to carry out bacteriological analyzes to search for microorganisms which are indicators of faecal pollution, especially faecal coliforms and faecal streptococci.

3.2.1 Coliforms

The term "coliform" refers to the different species belonging to the gram negative Enterobacteriaceae family, aerobic or optionally anaerobic, non-sporogonal and whose Main characteristic is the fermentation of lactose with gas production [**6**].

*** Fecal coliforms (CF).**

According to the World Health Organization [**7**], the faecal coliforms are Gram-, aerobic and facultative anaerobic, rod-shaped, non-sporulating bacteria that ferment lactose by producing gas, within 24 hours, at the same time they growth at 44°C on the medium Tergitol 7 Agar. Faecal coliforms have a highly significant positive correlation with faecal contamination caused by humans or warm-blooded animals, and are therefore a good indicator of the health quality of coastal waters [**8**]. This is based on the fact that *Echerichia coli* can't survive for a long time in the environment. Its survival time depends on several physicochemical factors, temperature is the essential factor that affects its concentration. Other work [**9**], show that the density of faecal coliforms and directly proportional to the biological oxygen demand (BOD_5). So their presence in the water always indicates a recent faecal contamination.

*** Fecal Streptococci (SF).**

Faecal Streptococci are slightly oval, Gram-positive, spherical cocci in the form of pairs or short chains during their growth on Slanetz and Bartely medium containing 2,3,5 triphenyl tetrazolium chloride (TTC).

The group of fecal streptococci normally comes from human intestines or warm-blooded animals and indicates faecal pollution when they are detected in seawater. Their mortality rate depends on salinity, temperature and solar radiation,...etc.

3.2.2 Enumeration of Fecal Coliforms

*** Filter membrane method**

The membrane filter method is the method used for the enumeration of fecal coliforms and fecal streptococci. This method is suitable for the enumeration of faecal coliforms and faecal streptococci in coastal bathing waters of temperate seas. It has been established for sanitary surveillance of beaches [**10-13**].

- **Principle:**

The method consists in filtering a volume of seawater sample taken under sterile conditions, according to the quantity of coliforms estimated in the water sample. The filtration membrane should have a pore diameter of 0.45 µm optimal for the total retention of bacteria. The membrane is placed on the surface of the culture medium poured into Petri dishes and cultured. After incubation the cultures are examined for bacterial colonies with specific characteristics and count to deduce the bacterial concentration per 100 ml of water (**Fig.9**).

- **Interpretation:**

Sodium heptadecyl sulfate (Tergitol 7) inhibits unwanted secondary flora. The degradation of lactose to acid is revealed by a yellow turn of the pH indicator, bromothymol blue, biphenyl chloride 2,3,5 tetrazolium (TTC) is reduced very rapidly by almost all coliforms except *Escherichia coli* and *Enterobacter aerogens* which give a red coloring.

Yellow colonies with yellow halo ⟶ *Escherichia coli*

Red with possibly yellow halo ⟶ Coliforms without *E. coli*

- **Confirmatory test**:

Faecal coliform colonies presumed on Tergitol 7 Agar medium are confirmed on bright green bilious lactose medium at 37 ± 1 °C for 24-48h.

- **Interpretation**:

Cloudy medium and presence of gas under the bell ⟶ Fermentation of lactose ⟶ Coliforms.

FIGURE 9: Bacterial culture

3.2.3 Enumeration of Fecal Streptococci

For Enterococci on membrane filters, selective Agar is used according to Slanetz and Bartley. This medium contains an abundant amount of nutrients to ensure good growth. On the other hand, all secondary flora is inhibited by azide.

- **Interpretation:**

Enterococci colonies reduce TTC to red-colored formazan, which allows early identification of yellow Escherichia coli colonies.

Pink to brown colonies with a diameter of 0.5 to 2 mm are usually fecal streptococci.

- **Confirmatory test:**

Fecal Streptococci colonies presumed on Slanetz & Bartley medium are confirmed on Litskey medium at 37 ± 1 ° C for 24-48h. Tubes with a disorder are considered positive and taken into account for the enumeration of fecal streptococci.

3.3 Method of classification of bathing waters

For the classification of bathing waters four categories are distinguished namely: **A**, **B**, **C** and **D** on the basis of the overrun of the Moroccan standards [**1**] for monitoring the quality of bathing water (**Tab.1**) and the international standards and guidelines for the sanitary monitoring of bathing waters [**14-15**].

TABLE 1
GUIDE VALUES AND IMPERATIVE VALUES SET BY THE MOROCCAN STANDARD NM 03.7.200 [1].

Parameters	Guide Value VG UFC/100mL	Imperative Value VI UFC/100mL
Fecal Coliforms	100	2000
Fecal Streptococci	100	400

*** Category A**: Good quality waters for swimming.

- At least 80% of Escherichia coli or faecal coliform results are less than or equal to the guideline value of 100 bacteria / 100mL;
- At least 95% of the results in E. coli or faecal coliforms are less than or equal to the mandatory value of 2000 bacteria / 100 mL;
- At least 90% of fecal Streptococci results are less than or equal to the guideline value of 100 bacteria / 100 mL.

* **Category B**: Medium quality waters for swimming.

- The water quality is medium when the imperative number set by the directive for E. coli and faecal coliforms of 2000 CFU / 100mL is respected in less than 95% of the samples.

* **Category C**: Waters temporarily polluted.

- Water monitoring points for which the frequency of exceeding the mandatory number for E. coli or faecal coliforms is between 5% and 33.3% is considered to be temporarily polluted. This pollution can be the subject of immediate or medium-term measures to permanently improve the quality of water.
- It is important to note that if less than 20 samples are taken during the whole season on one point, a single exceeding of the imperative number in E. coli or faecal coliforms, is enough to cause the classification of the beach in category C.

* **Category D**: Poor quality waters.

- Where, for the E. coli or faecal coliform parameter, the conditions relating to the imperative number are exceeded at least once in three, the bathing water concerned is considered to be of poor quality. All areas classified as Category D for two consecutive years shall be prohibited from swimming unless significant improvements occur.

Waters classified in categories **A** or **B** comply with the bathing standard, however, waters classified in categories **C** or **D** do not comply with the standard.

IV. RESULTS AND DISCUSSION

During our surveillance mission, several bathing water samples were taken at the Main beaches of the region Oued Eddahab-Dakhla Bay. Monitoring includes bi-monthly beaches visits, climate surveys, physicochemical measurements and microbiological analyzes (faecal coliforms, faecal streptococci and *Escherichia coli*).

The Main results of the analyzed parameters "in situ" and the microbiology laboratory of the National Institute of Fisheries Research Dakhla (**INRH**) are summarized in Figures 10-14 and Tables 2 to 10.

4.1 In the Al Moussafir beach,

The population of bathers or swimming increase from 2015 to 2017. The maximum of beach visitors are observed in the months of July and August (=700 persons) (Figure 10). The increase of temperature is also favorable for swimming (Figure

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **A** because of:

*the contamination standard is exceeded only in 27% of samples for Fecal coliforms and only in 2017 (**Fig. 11**);

*the Fecal Streptococci is exceeded only in 18% of samples in 2016 and 2017 (**Fig. 12**);

*the contamination standard by *Escherichia coli* never exceeded the standard of samples in 2015-2017 (**Fig. 13**);

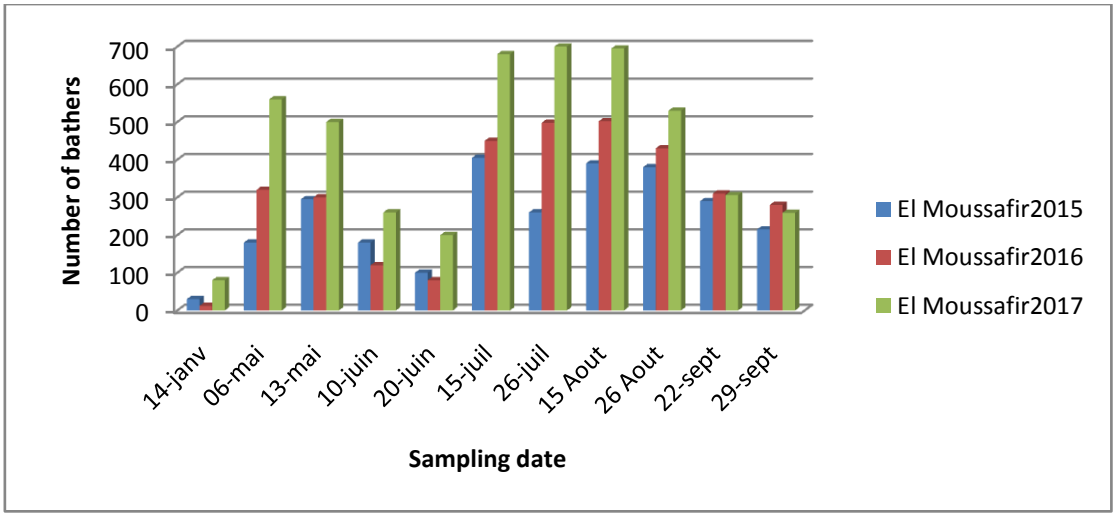

FIGURE 10: Monthly variation of bathers in Al Moussafir beach during years 2015-2017

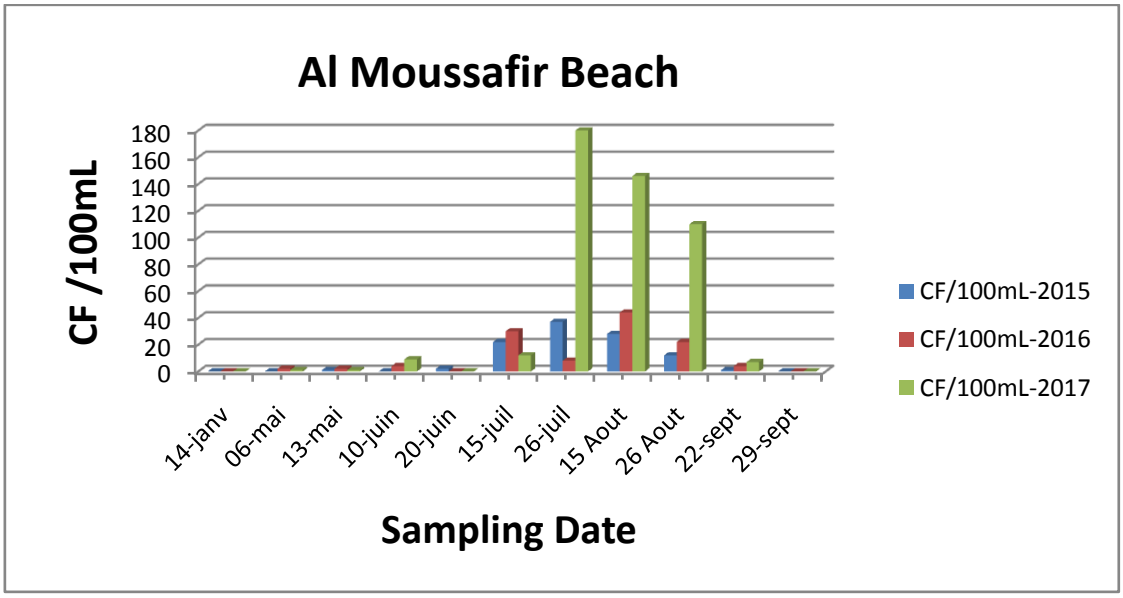

FIGURE 11 : Monthly variation of Fecal Coliforms in Al Moussafir beach during years 2015-2017

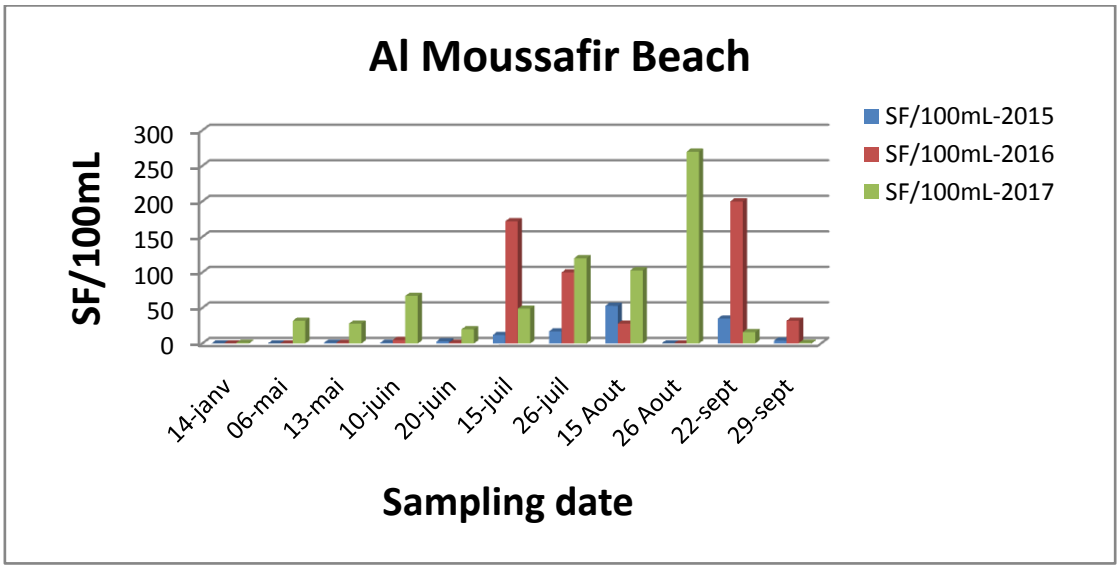

FIGURE 12 : Monthly variation of Fecal Steroptococci in Al Moussafir beach during years 2015-2017

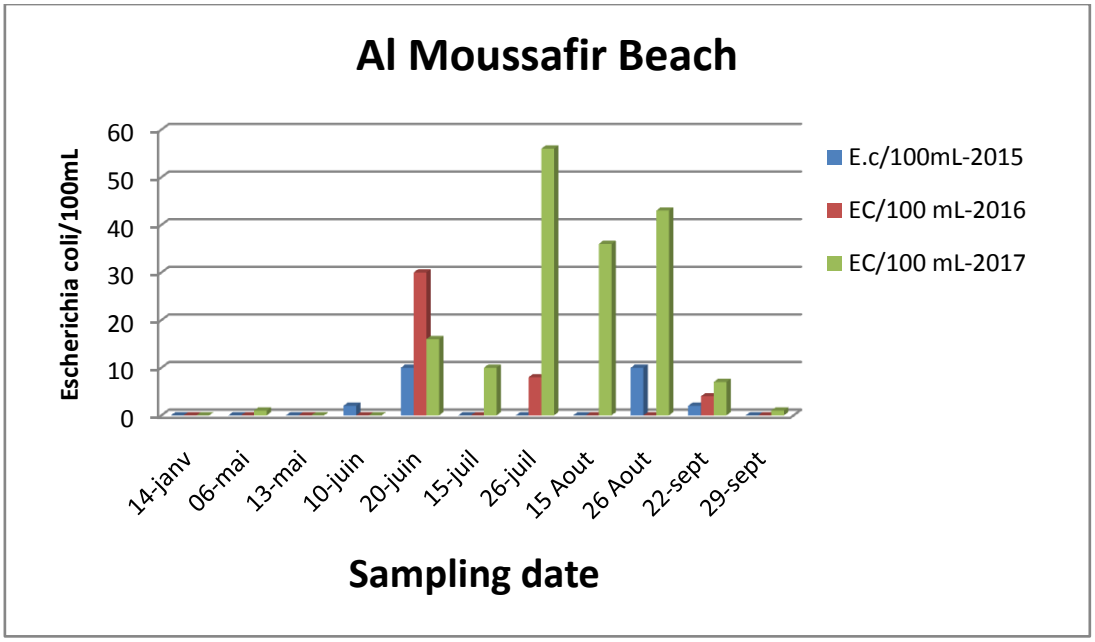

FIGURE 13 : Monthly variation of *Escherichia coli* in Al Moussafir beach during years 2015-2017

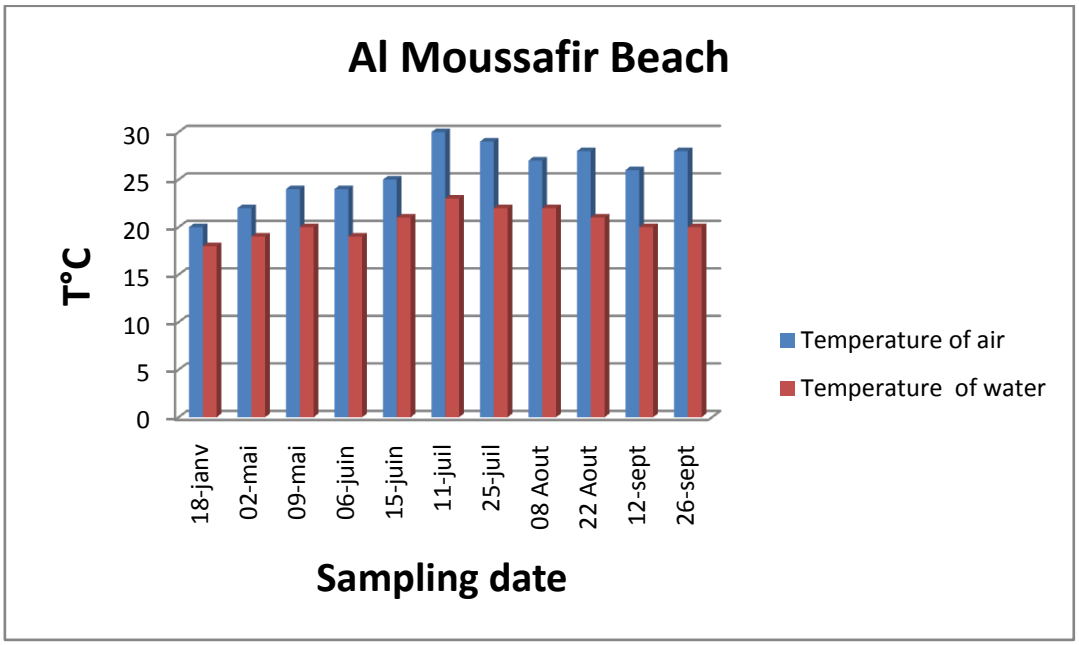

FIGURE 14 : Monthly variation of temperature in Al Moussafir beach during years 2015.

4.2 In the Foum Lebouir beach

The population of bathers or swimming increase from 2015 to 2017 beginning with 80 bathers in 2015. The maximum of beach visitors are observed in the months of July and August (=850 persons) (**Tab. 2-4**).

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **A** in 2015 and 2016 but must be degraded to rank **B** in 2017 because of:

* the contamination standard is exceeded in 30% for faecal coliform samples as of 2017 (**Tab. 4**);

4.3 In the LaKheira beach,

The population of bathers or swimming increase from 2015 to 2017 beginning with 12 bathers in 2015. The maximum of beach visitors are observed in the months of July and August (=358 persons) (**Tab. 5-7**).

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **A** in 2015 because of:

* the contamination standard not exceeded in 9% for faecal coliform samples in 2015 (**Tab. 5**);

* the contamination standard not exceeded in 9% for faecal streptococci samples in 2015 (**Tab. 5**);

* the standard of *Escherichia coli* contamination was exceeded in none of the samples (0%) in 2015 (**Tab. 5**);

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **B** in 2016 because of:

* the contamination standard exceeded in 64% for faecal coliform samples in 2016 (**Tab. 6**);

* the contamination standard exceeded in 64% for faecal streptococci samples (**Tab. 6**);

* the contamination exceeded imperative value (>400 UFC/100mL) for Streptococci but not for coliforms (<2000UFC/100mL) in 2016;

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **C** in 2017 because of:

* the contamination standard exceeded in 100% for faecal coliform samples in 2017 (**Tab. 7**);

* the contamination standard exceeded in 91% for faecal streptococci samples (**Tab. 7**);

* the contamination exceeded imperative value (>2000 UFC/100mL) in 1 from 11 samples in 2017 (**Tab.7**);

The relatively high percentages of exceedance for faecal coliform guideline values were recorded at the beaches of Lakheira, with over 64% exceedance (**Tab. 5-7**). The highest percentages of contamination not faecal coliforms and streptococci increase with years. This highest level were correlated to increase of wastewaters from 2015 to 2017 by addition of new agro industry (canning fish) (**Fig. 15**).

TABLE 2
MONTHLY VARIATION OF BACTERIAL CONTAMINATION OF FOUM LEBOUIR BEACH (2015).

Date 2015	Temperature		Tide	Bathers	CF/100mL	SF/100mL	E.C/100mL
	Air	Water					
18-January	20	18	High	16	1	0	0
02-May	22	18	High	55	70	0	0
09-May	24	18,5	Low	64	76	0	0
06-June	24	18	High	70	68	0	0
15-June	25	20	Low	30	0	15	0
11-July	30	24	Low	78	36	10	4
25-July	29	24	High	80	40	17	2
08-August	27	20	Low	90	14	12	0
22-August	28	21	Low	90	8	46	15
12-September	26	20	High	35	0	12	0
26- September	28	20	Low	28	2	3	0

TABLE 3
MONTHLY VARIATION OF BACTERIAL CONTAMINATION OF FOUM LEBOUIR BEACH (2016).

Date 2016	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EI/100 mL
	Air	Water					
26-January	22	19	High	35	0	1	0
07-May	23	19,5	High	90	70	0	0
14-May	22	19	Low	96	76	0	0
16-June	24	18	High	40	68	1	0
22-June	29	19	Low	60	72	5	0
16-July	32	24	Low	199	56	11	14
25-July	30	24	High	180	51	17	0
06 August	28	20	Low	170	60	190	0
25 August	27	20	Low	160	41	52	0
09-September	26	20	Low	105	4	104	14
23-September	27	20	High	90	4	40	0

TABLE 4
MONTHLY VARIATION OF BACTERIOLOGICAL AND PHYSICO-CHEMICAL OF FOUM LEBOUIR BEACH (2017)

Date 2017	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100mL
	Air	Water					
14-January	20	19	High	70	5	0	0
06-May	22	18	Low	350	10	0	0
13-May	22	19	High	320	12	0	0
10-June	26	20	High	220	50	3	1
20-June	26	21	Low	200	117	40	15
15-July	25	19	High	430	72	9	3
26-July	26	20	Low	460	26	6	1
15 August	30	24	High	700	202	2	0
26 August	23	22	High	850	165	195	12
22-September	22	20	High	580	23	29	3
29-September	24	20	Low	440	12	14	2

TABLE 5
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE LAKHEIRA BEACH (2015).

Date 2015	Temperature		Tide	Bathers	CF/100mL	SF/100mL	CF/100mL
	Air	Water					
18-January	20	18	High	12	50	32	3
02-May	22	18,5	High	120	80	57	10
09-May	24	18	Low	190	70	63	52
06-June	24	19	High	140	103	72	18
15-June	25	20	Low	50	75	82	0
11-July	30	23,5	Low	70	89	67	18
25-July	29	24	High	240	81	90	30
08 August	27	20	Low	248	99	67	0
22August	28	22	Low	257	56	120	19
12-September	26	20	High	180	60	32	2
26-September	28	20	Low	188	45	16	0

TABLE 6
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE LAKHEIRA BEACH (2016)

Date 2016	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC /100mL
	Air	Water					
26-January	20	18	High	30	90	56	12
07-May	23	20	High	170	120	96	0
14-May	22	19	Low	210	320	76	210
16-June	24	19	High	80	140	118	0
22-June	29	20	Low	110	98	108	44
16-July	32	23,5	Low	299	580	460	13
25-July	30	25	High	250	41	207	30
06 August	28	21	Low	260	120	118	70
25 August	27	20	Low	230	180	360	0
09-September	26	21	Low	120	90	44	16
23-September	27	18	High	90	152	400	10

TABLE 7
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE LAKHEIRA BEACH (2017)

Date 2017	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100 mL
	Air	Water					
17-January	20	19	High	45	210	60	24
06-May	22	19	Low	240	140	120	12
13-May	22	19	High	300	326	110	56
10-June	26	21	High	180	410	136	60
20-June	26	21	Law	120	>2000	350	230
15-July	25	19.5	High	340	256	184	30
26-July	26	21	Law	358	461	280	18
15 August	30	23	High	320	390	190	83
26 August	23	22	High	280	156	196	42
22-September	22	20	High	120	340	370	38
29-September	24	20	Law	98	180	347	180

FIGURE 15: Spreading of raw sewage on Lakheira beach

4.4 In the Tourist PK25 beach

The population of bathers or swimming strongly increase from 2015 to 2017. The maximum of beach visitors are observed in the months of July and August (=1400 bathers) (**Tab.8-10**).

In our monitoring of the bacterial load of beaches, it has been found that this beach must be classified **A** because of:

*the contamination standard is exceeded only in 9% of samples for Fecal coliforms and only in 2015 (**Tab.8-10**);

*the Fecal Streptococci is exceeded only in 18% of samples only in 2015 (**Tab.8-10**);

*the contamination standard by *Escherichia coli* never exceeded the standard of samples in 2015-2017 (**Tab.8-10**);

TABLE 8
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE TOURIST BEACH PK 25 (2015)

Date 2015	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100 mL
	Air	Water					
18-January	20	18	High	480	15	0	0
02-May	21	19	High	665	66	10	0
09-May	23	20	Low	447	73	13	0
06-June	23	19	High	480	54	90	2
15-June	24	21	Low	345	67	131	23
11-July	28	25	Low	367	171	112	12
25-July	28	25	High	388	57	34	0
08 August	26	22	Low	557	87	32	2
22 August	28	21	Low	630	38	12	0
12-September	26	20	High	450	19	4	9
26-September	28	20	Low	510	23	11	1

TABLE 9
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE TOURISTIC BEACH PK 25-28 (2016)

Date 2016	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100mL
	Air	Water					
26-January	20	19	High	420	0	0	0
07-May	22	20	High	768	12	0	0
14-May	21,5	19,5	Law	690	35	3	1
16-June	23	20	High	580	65	24	8
22-June	28	21	Law	470	44	5	0
16-July	31	24,5	Law	664	56	11	4
25-July	29	22	High	980	72	70	6
06 August	27,5	21	Low	788	47	3	0
25 August	28	21	Low	680	0	15	0
12-September	26	20	High	520	12	18	8
26-September	28	20	Law	610	36	56	7

TABLE 10
MONTHLY VARIATION IN BACTERIAL CONTAMINATION OF THE PK 25S BEACH (2017).

Date 2017	Temperature		Tide	Bathers	CF/100mL	SF/100mL	EC/100mL
	Air	Water					
07-January	20	19	High	890	1	0	0
06-May	21,5	19	Law	1010	13	7	0
13-May	21	19,5	High	800	17	1	0
10-June	26	21	High	1100	24	13	1
20-June	25	21	Law	980	9	1	0
15-July	24	19,5	High	1050	65	36	9
26-July	25,5	21	Law	970	70	50	26
15 August	29	24	High	1400	12	3	0
26 August	23	22	High	1350	60	19	12
22-September	22	20	High	1100	58	27	20
29-September	24	20	Law	1200	15	8	1

V. CONCLUSION

The assessment of the quality of the beaches that were monitored during the 2015 to 2017 surveys based on the Moroccan standard NM 03.7.200 (**Tab.1**) and the classification grid made it possible to list the clean beaches and the beaches. improper ranges and prioritize them as follows:

- The beache of **Al Moussafir** is classified **A** in all years 2015 to 2017;
- The beache of **Foum Lebouir** is classified **A** in 2015 and **B** in 2017;
- The beach of Tourist PK beach is classified **A** in all years 2015 to 2017;
- Unfortunately, the Lakheira beach deteriorates from class **A** to **B** then to **C** between 2015 and 2017. This decline was attributed to the increase in the number of tourists and the raw sewage flows discharged directly to the beach level.

In addition, the annual evolution of beach safety has shown a significant increase in bacterial contamination during the summer period, which begins in May-June. The highest infections are noted in July and August and decrease in spring and winter. This variation in the level of contamination is explained by the following facts:

- The beginning of the seaside activity by the occupation of the secondary houses at the edge of the beaches and the swimming start at the end of May;
- The school holidays in July August coincide with the maximum contaminations;
- The increase in the number of summer visitors in coastal cities, which has an impact on pollution flows from coastal emissions;
- Increased flow of tourists and Moroccans living abroad.

Observations made in the field during the summer have shown that the density of summer visitors is maximum in the afternoon, it is even more during the weekend (**Table 2-10**). The flow of holidaymakers reaches its peak especially during the months of July and August; period when all homes, hotels and inns are over-saturated.

The waters sampled at the beaches of Foum Lebouir and Lakheira are of average quality for bathing because of a more pronounced contamination by the indicator germs of fecal contamination. This pollution and degradation of the environment are mainly related to the activities of summer visitors during the summer. The temperature and pH of water are favorable for the survival of bacteria (**Table 2-10**).

This contamination is aggravated by the lack of infrastructure (garbage cans, toilets, showers, signs, etc.), the lack of liquid sanitation networks and the use of septic tanks and poor solid waste management.

Lakheira beach has an poor quality for swimming. It is a special ecosystem due to the presence of agro industry unit which reject rough wastewaters. In fact, the pollution generated is very impressive because of the tourists and industrial activities.

In fact, the sewage as soon as they arrive in the rivers is diluted by the rains. Similarly, domestic pollution is dampened by industrial and agricultural waste rich in heavy metals and pesticides that prevent the proliferation of microorganisms due to bacterial inhibition by toxicity and eutrophication.

The beaches of the **Al Moussafir** and **Tourist PK25** are of good quality for swimming due to the absence of wastewater discharges and also the low pressure of pollution.

In conclusion of our study it appears that the efforts made by the Moroccan government to preserve the environmental quality of beaches must be reinforced by:

- activation of the establishment of wastewater treatment plants and the necessary and adequate sanitation systems, both for solid discharges and for liquid discharges in coastal cities;
- put in place and implement the legislative and regulatory measures necessary to preserve the coastline, notably through the activation of the enactment of the law on the protection of the coastline;
- ensure compliance with the provisions of the regulatory texts governing standards for direct and indirect discharges of wastewater;
- create a national institution responsible for coastal zone management;
- endow the shoreline with master plans and beaches with development plans for recreation, hygiene and safety infrastructures;
- provide the ports with the necessary means of decontamination;
- strengthen the beaches in material and human resources for safety, hygiene and cleaning.

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