International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 6 No. 2 June 2014, pp. 149-161

http://www.ijias.issr-journals.org/

Use of marine algae in the quality evaluation of the El-Jadida area water mass

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ABSTRACT: Macroalgae are a good element for assessing the ecological quality of coastal waters. As such, this indicator has been included in the strategy for monitoring coastal water masses. In view of results on this parameter during this first campaign determining the diversity and spatio-temporal distribution of marine algae in all stations concerned by the study, we were able to evaluate the health of the study area coast water mass. The algae distribution differs from one station to the other according to the season and according to human factors, to give a water mass at low quality.

KEYWORDS: macroalgae, ecological quality, diversity, water mass.

1 INTRODUCTION

With over 3000 km of coastline, hydrological conditions particularly favorable due to the upwelling existence, sunshine which extends almost the entire year, rocky coasts diversity and still little beat and a rich algal flora which combines very different biogeography groups, Morocco is endowed with great potential in terms of exploitable algal resources. Already present among the largest exporters of seaweed extracts (agar), country harvest essentially *Gelidium sesquipedale* (Turner) Thuret and *G. spinulosum* (C. Agardh) J. Agardh (90 to 95% of production, the remainder consisting of different species *Gracilaria*, *Laminaria* and *Gigartina* ([1]; [2]). In 1991, algae production amounted to around 7,500 tonnes [3] and in 2013 the production of raw algae reached 14388,781 tones [4]. Although raw seaweed is exported from Dakhla (southern Morocco) the main operating area is the El Jadida-Jorf Lasfar riding which provides 80% of exports about 500 tones of agar per year ([2], [5]). Apart from this very limited area, the rest of the Moroccan Atlantic coast conceals considerable potential for production and still virtually unexploited.

Since the early work of [6], the algological contributions made in Morocco was essentially floristic and taxonomic, the most important being those of ([7]; [8]) and ([9]; [10]). Few authors have studied the distribution and species composition in Morocco ([11]; [12]; [13]; [7]; [14]; [15]). However, the production areas development and the new deposits exploitation of depend on the knowledge deepening. We also need to study the water mass quality of the Moroccan Atlantic coast to control our mediation activities related to marine environment.

The implementation of the Water Framework Directive (WFD) involves the application of control points for the assessment of the ecological condition of coastal water masses. The macroalgae are a good item to assess the environmental quality of coastal waters. In this title, this indicator was retained in the monitoring strategy for coastal water masses. The methodology implemented for the subtidal part is based on the work of [16]. It is a simplified application of the protocol used in the framework of the monitoring network REBENT established in Europe and in Spain. This report deals with the application of the DCE protocol for the water mass to the side in four sites on the shoreline Doukkala.

This document presents investigations results carried out in 2013, for the subtidal area. The final goal being to determine the ecological status of studied sites waters mass.

2 METHODOLOGY

2.1 SITES LOCATION

For the field's algae characterization, sites chosen were defined between Oualidia and Azemmour; four sites have been chosen: Oualidia, Mly Abdellah, El-Jadida and Lahdida (figure 1).

Four sites chosen are defined in the bathymetric chart extension of those surveyed on the foreshore. Because of the subtidal area configuration in the various sites studied, rocky discontinuities and sand presence in some sites and pollution, we are limited to some sites only: Oualidia (reference Site), Mly Abdellah, El-Jadida (Sidi Daoui toward the port) and Azemmour (Lahdida ; closest to the Oued Oum R'ibe mouth).

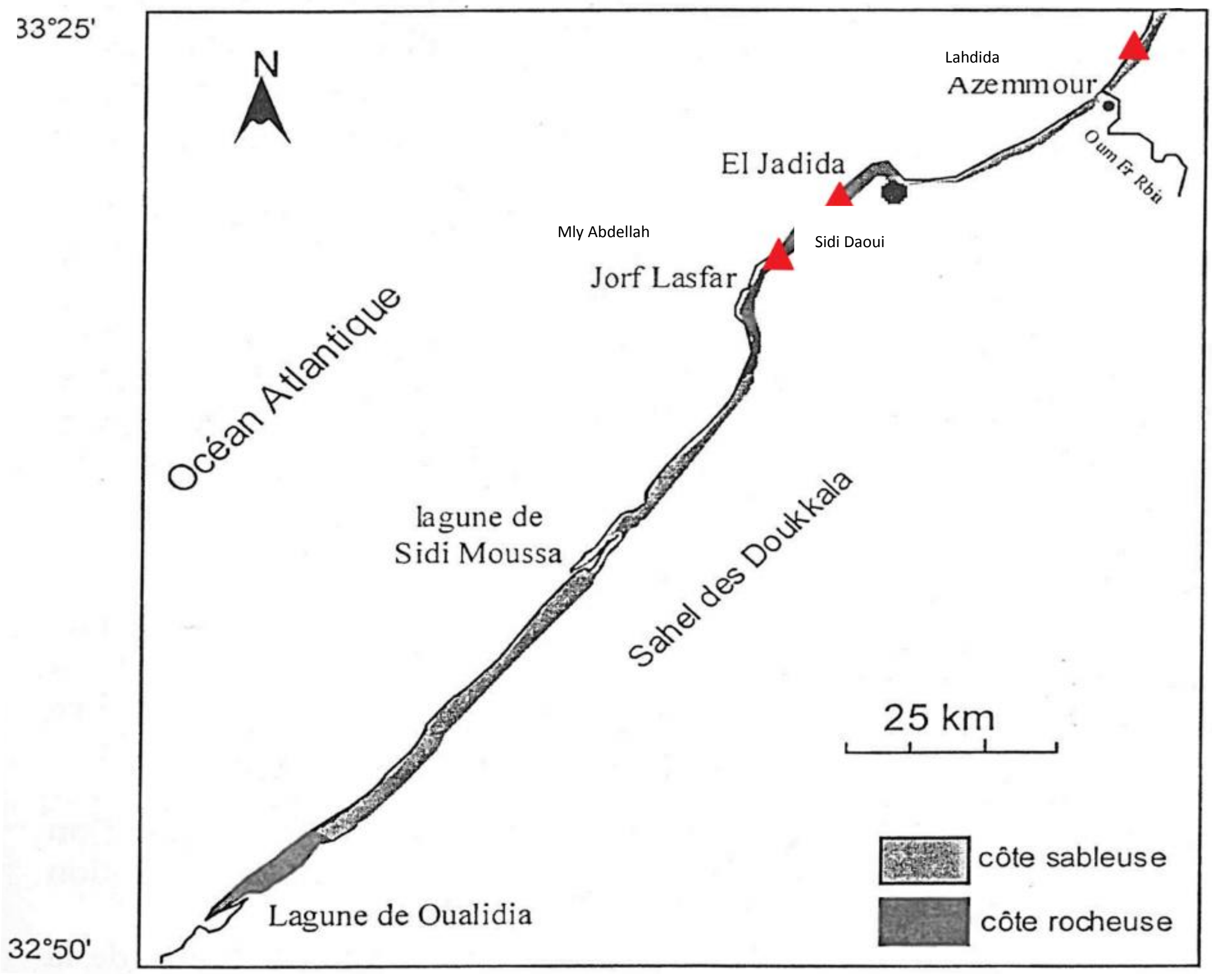

Figure 1: Location of surveyed sites

- Oualidia site has been taken as a reference site thanks to the quality of waters mass qualified for good.
- Mly Abdellah site was concerned by study, because it is characterized by a very important algal diversity and it is near the Complex Morocco Phosphorus which makes it a polluted site.
- Sidi Daoui site until the manifold of the industrial area north of the fishing port was chosen because of the presence of domestic sewage collector from the El-Jadida city, this site also receives wastewater from the slaughterhouse and those of the hospital Mohamed V; therefore is a source of major pollution of marine waters.
- Azemmour site is integrated in this study to assess the effect of Oued Oum Er Rabie mouth.

The dives carried out by site, with an average duration of ½ hr per dive, are carried out by bathymetric level (-3 m, -8 m, -13 m and -20 m) to acquire the data concerning the algal composition. Qualitative and quantitative measures are carried out in situ on quadrates of 1m^2. Quadrates are positioned in a random manner, the more nearly the bathymetry or within the seat belt (while avoiding flaws, steep slopes and sediment). The configuration in gentle slope of the area being surveyed and the limited time per dive limit the acquisition of data including to delimit the extension bathymetric chart of each level.

It is to be noted that the substrate is highly heterogeneous on all studied sites for bathymetric levels concerned. The presence of sand on some sectors will lead to the modification of adirondacks localization.

2.2 Intervention timetable

Investigations campaigns are scheduled during the first fortnight of mid-March 2013 up to mid-July 2013 in the four sites. The bathymetric levels taken into account can only be explored only in conditions of wave height to less than 1 m up to 1.5 m. On the other hand, for schedules reasons of tides and proximity, outputs part is done at the start of the El-Jadida port followed by the work done to Mly Abdellah and the other two at the outset of Oualidia (Sidi Moussa to Oualidia) and Azemmour (Lahdida at the Oued Oum Er Rabie mouth). Outputs will be on the day, with the possibility of achieving ten dives per site.

2.3 Work to achieve by bathymetric level

2.3.1 Implementation

A boat will be cabin cruiser for investigations achievement. The onboard equipment consists of a GPS kid 78 ® allows a marking from the surface. The sonar specifies the configuration and the site depth. Two divers in scientific immersion realize readings on quadrate and a third ensures the surface security as well as the boat cockpit. As well, the quadrate realization to the depth of preference will be preceded by a discovery stage to define the presence and abundance of structuring species (to apply adequate quadrates number).

The observation protocol DCE (the Water Framework Directive) proposed in this study and the calculation of the quality index for the indicator subtidal macro algae is the one proposed by the Europeans and the Spaniards for assessment of the water mass quality. The station anteriority in terms of subtidal funds rocky studies (Network Reent) constituted a serious asset to accomplish this work. This same observation protocol has been applied by several authors in different countries ([17]; [18]; [19]; [20]; [21], [22]).

We have defined our own monitoring strategy to assign to water masses an ecological status among 5 levels (very good, good, average, bad and very bad). The ecological condition assessment of coastal water masses must be done especially through biological parameters (subtidal macro algae). A relevant habitats selection has been carried out.

The work on each quadrate is to:

- Identify the macro-algae species presented; collect all the algae present on each quadrate;
- Assess the algal coverage percentage in situ by direct visualization; validation a posteriori on photo ;
- Species density the better represented; counting feet when this is possible for the larger species ;
- Specific richness per site calculated on the basis of 10 quadrates randomly selected among set of achieved quadrates.

It is also noted that epiphytic species are not taken into account in inventories qualitative and quantitative on quadrates.

2.3.2 Parameters investigated

To assign a quality index to a site, the parameters taken into account are the following:

- Species composition and density defining the grade separation (Fucales (*Fucus spiralis*) and other macroalgae participating in the definition of different seat belts) = structuring species ;
- Specific composition (characteristic species and opportunistic species) ;
- Total specific richness.

2.3.2.1 Species composition and density defining ranges

The presence and density of these species are identified at quadrates level positioned in the seat belts of levels 1-2 and level 3, by counting feet. The limit between the horizon to *Fucus spiralis* (seat belt which constitutes the lower limit of level 1) and the horizon to brown algae (*Fucus spiralis*) dense (level 2) does not need to be determined and it is considered a single seat belt to dense *Fucales* in consolidating these two horizons. However, the *Codium adhaerens* presence in the lower limits of the level 2 should be noted. Level 3 is characterized by the appearance of *Bifurcaria tuburculata* and *Dictyota dichotoma* with the red algae diversification.

2.3.2.2 SPECIFIC COMPOSITION

This note is the result of 3 sub-indices:

- Characteristic species: The parameter to integrate in the ecological sites qualification is the presence/absence of substratum characteristic species to brown algae structuring. In each level, it counts the number of characteristic species presented. For each of four ecoregions identified (Oualidia, Mly Abdellah, Sidi Daoui, Azemmour), characteristic species lists have been defined.

-Opportunistic species: These species are recorded in individual number and a note is assigned according to their total density for four stations. For each frame, the opportunistic species are counted and their density is calculated in feet number per m^2.

- Presence of indicator species of good ecological status: For each ecoregion, if one of the indicator species of good ecological status is present, a point is added to the average of the two sub-indices "characteristic species" and "opportunistic species".

- Presence of threatened or endangered species: the presence of these species characterized the coastal waters degradation level of each studied station.

2.3.2.3 TOTAL SPECIFIC RICHNESS

It is determined on 10 quadrates for all floors; superiors and median and lower. The floristic diversity corresponds to the total number of identified taxa within the sampling area corresponding to the level.

2.3.3 PROTOCOL FOR QUALITY INDEX AND EQR CALCULATION

The water masse types identified in this study are subdivided into three supertypes:

- Supertype A: rocky coast little turbide ;
- Supertype B: side sandy-muddy little turbide ;
- Supertype C: rocky coast or sandy-muddy turbid.

2.3.3.1 THE QUALITY INDEX

A rating scale system will allow assigning a note for each of the parameters investigated. Each of these notes will participate in the site quality index calculation.

a. Composition and density of species defining ranges

A different scale is applied according to the supertype belongs the water mass (Table 1).

Table 1: Rating scale (density of species defining the grade separation)

Density of species defining the grade separation (nb ind/m^2)		Note
Supertype A and B	Supertype C	
<10	<15	0
(10 ; 20[	(15 ; 30[	5
(20 ; 35[	(30 ; 45[	10
(35 ; 60[	[45 ; 60[	15
≥60	≥60	20

b. Specific composition

This note is the resultant of 3 sub-indices:

➢ **Characteristic species**

For each level, a count of characteristic species is achieved, which allows you to determine the characteristic species number well represented in each level. The scale (Table 2) allows, in function of the water mass supertype, to assign a note.

Table 2: Rating scale (characteristic species)

	Characteristic Species Number	Note
Supertype A or B	<9	0
	[9-12[	5
	[12-15[	10
	[15-18-[	15
	≥18	20
Supertype C	<5	0
	[5-8[	5
	[8-11[	10
	[11-14[	15
	≥14	20

➢ **Opportunistic species**

In each seat belt, the opportunistic species are counted within quadrates (10 quadrates selected at random). It then calculates their density (in number of feet / m^2). A single scale (Table 3) allows, whatever the level studied, give a score based on the total density of opportunistic species.

Table 3: Rating scale (opportunistic species).

Opportunistic Species Density (nd ind / m2)	Note
≥30	0
(20 ; 30[	5
[12 ; 20[	10
(7; 12[	15
(0 ; 7[	20

➢ **Indicator species of good ecological status**

For each of ecoregions, we evaluated the indicator species presence of good ecological status. If at least one of the indicator species is present on a site, an additional item is added to the average of two sub-indices "characteristic species" and "opportunistic species".

c. Total Specific Richness

In each frame, the algal diversity is measured by listing the species present. This allows to identify the taxa number on a minimum surface for sampling (10 quadrates in levels (1-2) and 10 quadrates in level 3). If for a level, quadrates number made is higher, then a draw random in order to obtain quadrates required number. Depending on the level studied, a notation grid (on 10 points) allows to characterize the site according to the total specific richness measured (Table 4).

Table 4: Rating scale: total specific richness.

	Supertype A	Supertype B or C	Note
Taxa number Identified on 10 quadrates	<15	<20	0
	(15 ; 20[	(20 ; 30[	5
	(20 ; 30[	(30 ; 40[	10
	(30 ; 40[	(40 ; 45[	15
	≥40	≥45	20

d. Site quality index Calculation

The site quality index is obtained by calculating the average (reported on 100 points) of notes obtained.

- Density species note in the defining grade separation (40pts);
- Specific composition note (40pts);
- Specific richness total note (20pts).

$$\mathbf{IQ} = \frac{\textbf{Note average of investigated parameters}}{\mathbf{100}}$$

2.3.3.2 EQR CALCULATION

The EQR or Ecological Quality Ratio is calculated by taking the ratio between a site quality index and the reference site quality index. Oualidia site is considered as a reference site because of its distance from the pollution and of rivers waters and its water mass is classified good.

$$\mathbf{EQR} = \frac{\mathbf{IQsi}}{\mathbf{IQsr}}$$

With: - **IQsi**: Quality Index of each studied station;
- **IQsr**: Quality Index of the reference station.

2.3.3.3 READING GRID

A reading grid allows a function of EQR in site 0 and 1, to characterize the ecological status of the water mass concerned in accordance with the table (5).

Table 5: EQR reading grid

[0 ; 0.25 [	**Very bad**
[0.25 ; 0.45 [	**Bad**
[0 ;45 ; 0.65 [	**Medium**
[0.65 ; 0.85 [	**Good**
[0.85 ; 1]	**Very good**

In cases where several sites are in the same water mass, we calculated the average EQR of these latter to qualify then the water mass.

3 RESULTS

3.1 SPECIES DEFINING RANGES COMPOSITION AND DENSITY

Species to be counted in four stations are presented in table (6).

Table 6: List of species defining ranges

	Upper range	Median range	Lower range
Chlorophycees	- *Ulva spp* - *Enteromorpha spp*	- *Ulva spp* - *Enteromorpha spp* - *Codium adhaerens*	- *Ulva spp* - *Enteromorpha spp* - *Codium tomentosum* - *Codium adhaerens*
Pheophycees	- *Fucus spiralis*	- *Fucus spiralis*	- *Fucus spiralis* - *Bifurcaria tuburculata* - *Dictyota dichotoma*
Rhodophycees	-*Corallina spp* -*Caulacanthus ustulatus*	-*Caulacanthus ustulatus*	-*Caulacanthus ustulatus* - *Gigartina acicularis* - *Gelidium spinulosum* - *Laurencia pinnatifida* - *Corralina elongata* - *Gelidium sesquipedale* - *Halopithys incurvus*

3.2 SPECIFIC COMPOSITION

- Characteristic species

The characteristic species presence is regarded as a testimony of a good ecological status of the middle (table 7). As well, the more their number is high and more the number of points allocated is large.

Table 7: Characteristic species list of four stations studied

	Oualidia	**Mly Abdellah**	**El-Jadida (Sidi Daoui toward the port)**	**Azemmour**
Chlorophycees	*-Ulva spp* *-Enteromorpha spp* *-Codium tomentosum* *-Bryopsis balbisiana* *-Chaetomorpha linum*	*-Ulva spp* *-Enteromorpha spp* *-Codium adhaerens* *-Codium tomentosum* *-Ulva lactuca* *-Blidingia marginata*	*-Ulva rigida* *-Ulva lactuca* *-Chaetomorpha aerea* *-Blidingia marginata* *-Halicystis parvula*	*-Ulva spp* *-Enteromorpha spp* *-Bryopsis pennata* *-Cladophora pellucida*
Rhodophycees	*-Corallina spp* *-Caulacanthus ustulatus* *-Callophyllis laciniata* *-Gelidium spp* *-Chondracanthus acicularis* *-Ustulatus acicularis* *-Laurencia pinnatifida* *-Phyllophora crispa* *-Polysiphonia complanata* *-Nitophyllum punctatum* *-Pterosiphonia complanata* *-Pterosiphonia pennata* *-Rhodophyllis divaricata* *-Calliblepharis ciliata* *-Porphyra umbilicalis* *-Lithophyllum decussatum*	*-Caulacanthus ustulatus* *-Gigartina acicularis* *-Gigartina pistillata* *-Gelidium spinulosum* *-Laurencia pinnatifida* *-Corralina elongata* *-Gelidium sesquipedale* *-Halopithys incurvus* *-Corallina officinalis* *-Gelidium sesquipedale* *-Gymnogongrus griffithsia* *-Calliblepharis ciliate* *-Calliblepharis jubata* *-Mesophyllum lichenoides* *-Nitophyllum punctatum* *- Phyllophora crispa* *-Plocamium cartilagineum* *- Jania rubens* *-Pterosiphonia complanata* *-Pterosiphonia pennata*	*-Corallina elongata* *-Grateloupia lanceola* *-Lithophyllum incrustans* *-Caulacanthus ustulatus* *-Chondracanthus teedei* *-Mastocarpus stellatus* *-Chondrea cappilaris* *-Jania rubens* *-Lithophyllum lichenoides* *-Pterosiphonia complanata* *-Gelidium sesquipedale* *-Gracilaria multipartita* *-Titanoderma pustulatum*	*-Caulacanthus ustulatus* *-Gelidium sesquipedale* *-Gracilaria multipartita* *-Lithophyllum byssoides* *-Corallina officinalis* *-Palmaria palmata* *-Heterosiphonia plumosa*
Pheophycees	*-Fucus spiralis* *-Bifurcaria Bifurcata* *-Taonia atomaria* *-Dictyopteris polypodioides* *-Petalonia fascia* *-Sphacelaria radicans* *-Cystoseira humilis* *-Cystoseira tamariscifolia* *- Cystoseira nodicaulis* *-Sargassum acinarium* *-Sphacelaria brachygonia*	*-Fucus spiralis* *-Bifurcaria Bifurcata* *-Dictyota dichotoma* *-Cystoseira baccata* *-Cystoseira humilis* *-Cystoseira tamariscifolia* *-Halopteris scoparia* *-Dictyopteris polypodioides*	*-Fucus spiralis* *-Halopteris scoparia* *-Sphacelaria radicans* *-Pilinia rimosa* *-Laminaria ochroleuca* *-Dictyota spiralis* *-Cystoseira humilis* *-Taonia atomaria* *-Elachista flaccida*	*-Fucus spiralis* *-Petalonia fascia* *-Halopteris filicina* *-Laminaria ochroleuca* *-Culteria adspersa*

-Opportunistic Species

They are considered as an environmental degradation indicator in link with a human activity effect. When their number and density increase, point number assigned decreased (Table 8).

Table 8: Opportunistic species list

Taxonomic group	species
Chlorophycees	*- Ulva lactuca* *- Ulva rigida* *- Ulva fasciata* *- Enteromorpha intestinalis* *- Enteromorpha prolifera* *- Chaetomorpha aera* *- Chaetomorpha linum*
Pheophycees	*-Scytosiphon lomentaria* *-Laminaria ochroleuca* *-Sacchoriza bulbosa*
Rhodophycees	*-Gelidium latifolium* *-Hypnea musciformis* *-Caulacanthus ustulatus* *-Griffithsia opuntioides* *-Antithamnion cruciatum* *-Centroceras clavulatum*

- <u>Presence of good ecological status indicator species</u>

These species are: Laminaria digitata, Padina pavonica and Gelidium corneum.

- <u>Presence of threatened or endangered species</u>

The presence of these species shows a high level of marine environment degradation (Table 9).

Table 9: List of threatened or endangered species (Riadi and all, 1998)

Taxonomic group	Species	Gravity of threat	Types of threats
Chlorophycees	*-Ulva fasciata* *-Bryopsis plumosa* *-Bryopsis balbisiana*	*** *** ***	-Waste Water household and industrial. -Strong urbanization. -Adulterated naval.
Pheophycees	*-Halopteris scoparia* *-Halopteris filicina* *-Padina pavonica*	*** *** ***	Urban Pollution and industrial.
	-Laminaria ochroleuca *-Sacchoriza bulbosa*	*** ***	Surface Contamination of coastal and marine waters.
Rhodophycees	*-Gelidium sesquipedale* *-Gelidium spinulosum* *-Gelidium latifolium* *-Gelidium pulchellum* *-Gelidium crinale* *-Gelidium pusillum*	*** *** *** *** *** ***	-Intense grubbing. -Biological rest period non respected. -Pollution.
	-Gracilaria multipartita *-Gracilaria cervicomis* *-Gigartina pistillata*	*** *** ***	-Urban pollution and industrial.

3.3 TOTAL SPECIFIC RICHNESS

Species richness of each station is constituted by all species defined by the study conducted by Hanif N. et al [23] in the same study area.

3.4 FINAL NOTATIONS AND SITES QUALIFICATION

The quality index (QI) is the result of 4 studied parameters. This IQ is divided by reference index for the final rating EQR calculation (Table 11).

Table 11: Classification grid of surveyed sites

Sites	IQ	Reference (Oualidia)	EQR	Qualification
Mly Abdellah	38	72	0.52	Medium
El-Jadida	21	72	0.29	Bad
Azemmour	49	72	0.68	good
Water mass	36	72	0.49	Medium

The EQR means for all of sites belonging to the water mass of Oualidia to Azemmour coast is of 0.49; which allows characterizing this parameter in quality "Medium".

4 DISCUSSION

The DCE protocol application (Water Framework Directive) for the quality monitoring of the littoral Doukkala water mass shows that it is described as bad. This comprehensive qualification could be explained, in part at least, by fact that coastal water mass is subject to a regular desalinated water related to the presence of a dense hydrographic network and of a significant rainfall. The main vector of freshwater and turbide at sea is Oum Er R'bie River in the water mass north; it drains the waters of its urbanized watershed. Because of the coastal currentology, and the littoral drift directed toward the south, the turbidity covers in flood periods a large portion of the water mass.

The water turbidity is linked to the suspended matter contribution, eutrophisation, and the sediment suspension. Turbidity can have various origins such as weather conditions (rainfall, storms), the amenities coastlines, the phytoplanktonic blooms and the rivers pollution...

The foreshore morphology (reef flat width and roughness), the substrate nature (sand or rock), the sediment presence and hydrodynamic instability influence largely the vegetation composition and structure [24]. For all communities studied, seasonal variations are closely related to environmental conditions and the dominant species life cycle. According to the evolution of algal phytocenoses model proposed by Ballesteros i Sagarra [25], we can distinguish two phases during the year, a "diversification phase" marked by a relatively balanced organization stand (maximum Equitability and diversity) then a "production phase" corresponding to the optimal development or dominant species (minimum Equitability and diversity). For *Fucus spiralis* belt, the first phase takes place in winter-spring and the second in summer-autumn. For Florideophycee communities, evolution is reversed with an organization period in summer-autumn and a production phase at the beginning of year [24]. For *G. sesquipedale*; from April to September growth is active, the weight gain is first due to the increase of the total number of branching and also to the frond elongation. From September seaweed is degraded of its fronds suite, either to the liberation of reproductive cells or to the natural fronds fragmentation by waves. Indeed, during this period, the fronds number harvested with grounding is important [26]. The same result was reported by [27] in *G. sesquipedale* populations in south of France, and by Mouradi A., and al., [28] in Mehdia site. *G. multipartita* species has low growth in winter and active growth in spring-summer and lightweight in autumn, similar results concerning growth periods were obtained by [29]. From September to October fronds become fragmented and disappear and in winter the individuals are in disc form [30].

Similar annual variations were observed on the Spanish Atlantic coast ([31]; [32]). In Morocco, this cyclical evolution can be affected by various environmental agents (storms, sand encroachment, and abrasion by the rollers, high desiccation, and mussel exploitation by man) which, by destroying stand, allow installation of transitional opportunistic ephemerophycees (Ulvophyceae).

This water mass is subject to a strong anthropogenic pressure and local communities have mobilized to improve the water quality with particularly significant remediation work to optimize the wastewater treatment. The entire set of physico-chemical changes of coastal waters have an influence on algal blooms communities that develop there.

The macroalgae and in particular some *Laminaria* are sensitive to the water temperature. A coastal waters warming could strongly influence *Laminaria* distribution (who could disappear from some sites) and the ecological status defines by the macroalgae indicator would be degraded.

The use of water mass quality index proved to be an effective tool for assessing the rocky ecological quality of coastal communities, based on the analysis of assemblages of macroalgae [33].

Algal diversity is largely influenced by variation of environmental parameters and pollution. Among environmental factors governing macrophyte distribution, temperature and day length are suggested to be the most relevant at a worldwide geographical scale [34]. Abiotic factors such as depth (light), salinity, substratum, nutrients, water motion, sedimentation and pollution affect the structure and distribution of algal communities at a local scale ([35]; [36]; [37]; [38]; [39]; [40]; [41]).

Macrophyte communities found at unpolluted sites in the study area are characterized by the presence of a perennial canopy of *Gelidium sesquipedale* or *Cystoseira baccata* growing over a basal layer of *Pterosiphonia complanata*, *Rhodymenia pseudopalmata* and *Corallina officinalis* [42]. Seasonally, an epiphytic layer of *Dictyota dichotoma* and *Plocamium cartilagineum* is developed preferentially on *G. sesquipedale*. When pollutants are introduced into the waters, the first vegetation response is the degradation of the perennial canopy, with *C. baccata* appearing to be more sensitive to pollution than *G. sesquipedale*. The development of certain species more tolerant to pollution such as *P. complanata* or *Codium decorticatum* is encouraged by the absence of the canopy, and they become the dominant species of the community. The decline of large perennial algae under the effect of pollution is the first sign of degradation ([43]; [44]; [45]; [46]; [47]).

In the study area, the large perennials *Cystoseira baccata* and *Gelidium sesquipedale* are partially replaced by the large annual *Codium decorticatum*. This fact has been reported by several authors ([48]; [47]) who have pointed out the replacement of *Cystoseira spp.* by species of *Codium* in polluted areas, whose development is encouraged by nutrient enrichment of the waters.

5 CONCLUSION

This first investigations campaign has allowed collecting information to calculate an environment quality index. However, some settings could not be defined and would require additional investigations to clarify the information collected and lead to an algae fields characterization as it is in the field.

The main difficulty which has arisen in this work relates to the fact that the species distribution and their densities are of benefit function of sites configuration and more particularly of the exposure to dominant swells. Thus, it would be desirable to test on the ground the protocol used by a high number of quadrates by extension of sampling area.

To optimize the quality index calculation, obtaining bathymetric limits levels (levels 1, 2 and 3) is required. It would also be interesting to define the depth that characterized beginning of each level. The collection of this information passes through new exploration which some more profound.

In conclusion, this first analysis of the intertidal and subtidal Phytobenthos for a Moroccan Atlantic coast portion in Doukkala coast still submerged by pollution can be an important point for monitoring water quality in the region. Finally, in terms of algal resources, it provides new information on various agarophytes (*Gelidium spp*. and *Gracilaria Multipartita*) and carraghénophytes (*Gigartina spp*. *Grateloupia spp*., *Mastocarpus stellatus* And *Gymnogongrus spp*.) potentially exploitable in Morocco.

ACKNOWLEDGEMENTS

We thank all participants in the sampling missions. The DPM persons of El Jadida are treasured thanked.

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