Journal of Applied Science and Environmental Studies
JASES
http://revues.imist.ma/index.php?journal=jases

Original Paper

THE CHECKLIST AND THE ECOLOGICAL INDEX OF THE BROWN SEAWEEDS FROM ESSAOUIRA COASTLINE (MOROCCO)

H. SABRI[1,2*], O. CHERIFI[1,2], A. MAAROUF[3], N. BAHAMMOU[1,2], Y. BOUNDIR[1,4]

[1]*Laboratory of Water, Biodiversity and Climate Change, Faculty of Sciences Semlalia, University Cadi Ayyad Marrakech, Morocco*
[2]*National Center for Studies and Research on Water and Energy, University Cadi Ayyad, Marrakech, Morocco*
[3]*Laboratory of Bioresources and food safety, Faculty of Sciences and Technics, University Cadi Ayyad, Marrakech, Morocco*
[4]*Environment and Health Team, Faculty of Polydisciplinary, University Cadi Ayyad, Safi, Morocco*

* Corresponding author. E-mail address: hasnae.sabri@ced.uca.ma

Received 28 May 2021; Revised 28 July 2021, Accepted 15 September 2021

Keywords
Seaweeds
Catalogue
Biodiversity
Ecological State Groups
Recovery Index
Atlantic coast

Abstract

The aim of the present work is to catalogue the upper subtidal and intertidal brown phytobenthos inhabiting three different coastal areas nearby Essaouira city, extended between 31° 52' N - 9° 75' W North and 31° 49' N - 9° 76' W South. This checklist of Pheophyceae is among the first revised and updated checklist for almost 20 years on the Atlantic Moroccan coastline. A total of 73 taxa belonging to 39 genera were recorded, with an increase of 15% in algal species compared to previous studies. Additionally, the benthic macroalgal species collected in different seasons of the year are shown, as well as a comparative analysis of the Ecological State Groups (ESG) and their Recovery Index (RI) for the three sampled coastal areas. The ecological data showed that the state of health of the reference station (S1) is good, in comparison to the other two impacted ones (S2 and S3), since the percentage of sensitive species in S1 (51%) is much higher than those in S2 (7%) and S3 (21%).

1. Introduction

With its vast coastline (3500 km in length) and particular biogeographical provinces: the western Mediterranean, the temperate Atlantic, and the warm temperate Atlantic (Moroccan Sahara), Morocco has in the past attracted numerous naturalists, who published diverse checklists of Moroccan marine seaweeds. Some of these studies are restricted to the Atlantic coast [1–6], whereas others have been focused only on the Mediterranean coast [7–9]. A later guide of algae

reported some other new species found earlier in 2002 and 2003 [10]. However, some stretches of coastline coasts are poorly or entirely neglected, especially the western Atlantic coast.

In the Essaouira region, the majority of the studies produced catalogues of marine benthic macroalgae based on scattered records, and the taxonomic status of reported species are mostly outdated. For example, the marine flora publications done by Gayral (1961) [4], Riadi and Kazzaz (1998) [11], and Benhissoune et al. (2002) [6], among others, included seaweeds occurring on the Essaouira coast such as a guidebook of Benhissoune (2020) [10] that updated seaweeds recorded during 2002. However, there are no details about the precisely investigated localities. One exception was the checklist of benthic macroalgal species done by Gayral (1957) [12] on the island of Mogador. In the past two decades, the marine botany studies have dealt either with algal bioproducts [13–15] or ecological aspects of marine vegetation, such as the use of seaweeds as bio-indicators [16, 17]. Where the latter paper has demonstrated the effects of anthropogenic activities on algal specific richness in some coastal areas in Essaouira city [18].

The overall aim of the current study is to deliver a solid baseline of the Essaouira benthic macroalgal taxa extant in three different coastal locations (impacted and non-impacted ones) on the Atlantic coast of Morocco. The present study updates the checklist of Phaeophyta and, at the same time, emphasizes the algal biodiversity disturbance due to anthropogenic pressures. This piece of research is the second part of a series of macroalgal studies including the red and green seaweeds from the same geographical area.

2. Materials and Methods

2.1. Characteristics of sampling sites

The present study was conducted at 3 coastal areas near Essaouira city and its suburbs (Fig. 1):

- S1: Moulay Bouzerktoune Station, located approximately 30 km away from the city (31° 63' N - 9° 67' W), is considered as a reference station, affected by ephemeral anthropogenic activities at the end of spring and during summer.
- S2: Bab Doukkala Station, the industrial district of Essaouira, located in the city north of the port (31°51' N - 9° 76' W). This urban coast receives mainly significant domestic and some industrial wastewater.
- S3: Port Station, another urban coast (31° 51' N - 9° 77' W) that receives some industrial and domestic discharges from the port and the city districts, respectively.

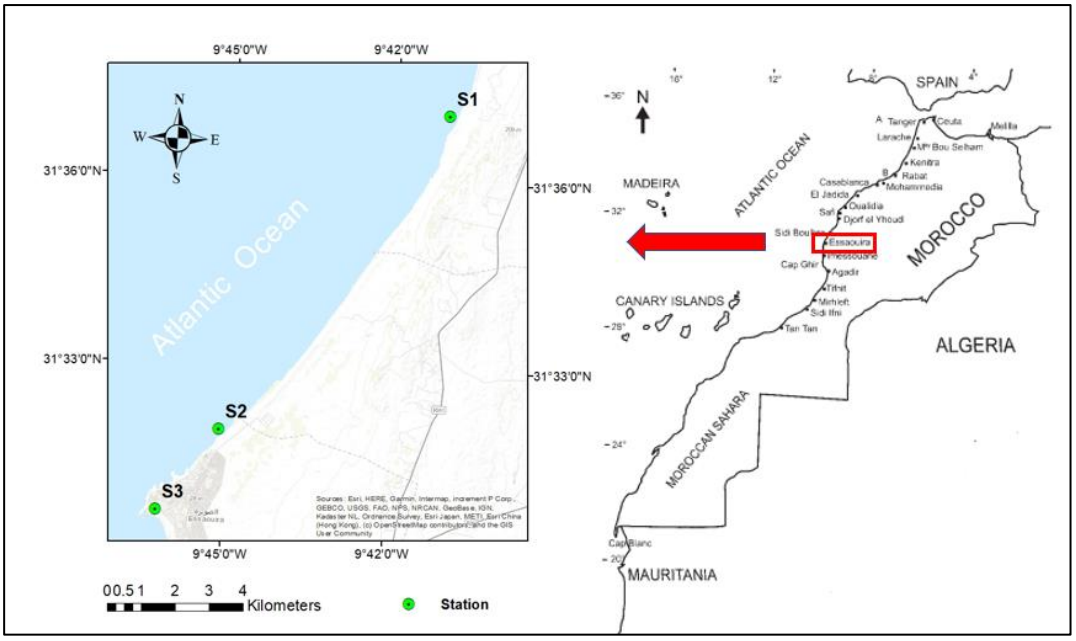

Figure 1: Geographical position of the study sites along the coast of Essaouira. (S1) Moulay Bouzerktoune: 31° 63' N - 9° 67' W – (S2) Bab Doukkala: 31° 51' N - 9° 76' W – (S3) Port of Essaouira: 31° 51' N - 9° 77' W

2.2. Sampling method and treatment of samples

Algal samples were collected seasonally at low tide (0 to 1.5 m) from autumn 2016 to summer 2018 (Autumn: October 2016 and November 2017; Winter: January 2017 and January 2018; Spring: April 2017 and May 2018; Summer: July 2017 and July 2018), following the quadrat methodology [19]. A total of 30 quadrats was provided for intertidal and subtidal zones to cover the heterogeneity of the macroalgal distribution pattern in the foreshore. Samples were then preserved in a seawater solution with 10% alcohol, put in a cooler and transferred to the laboratory. Seaweeds were identified in situ and in the laboratory with a dissecting and a compound light microscope using the pertinent scientific publications dealing with macroalgal taxonomy [5,6,11,20,21]. The hierarchical classification and the current taxonomic status for the concerned species were confirmed following AlgaeBase [22].

The global Recovery Index was carried out based on the number of individuals of each algal species in the quadrat, according to Braun-blanquet (1959) [23]. In addition, the seaweeds were classified into five ecological status groups, ESGI (IA, IB, IC; late-successional taxa), and ESGII (IIA, IIB; opportunistic taxa such as filamentous and sheet-like green algae) according to the classification proposed by Orfanidis et al. (2011) [24], to complete the index of the other species, we use other references [10,25–29].

3. Results

Table 1 shows the distribution of the benthic brown algae, inventoried along the Essaouira coast from October 2016 to July 2018. An important diversity has been shown with 73 species represented by 10 orders and 20 families of brown algae, where the greatest contribution comes from the orders Fucales and Ectocarpales with 20 and 19 species, respectively. Then, by Dictyotales and Sphacelariales with 11 and 10 species, respectively.

The inventoried algae were unevenly distributed. Indeed, coastal area (S1) exhibited a higher number of species than the other two sampled sites; a total number of 61, 18 and 28 algal species was recorded at S1, S2 and S3, respectively. In addition, at S1 (the northern station), the most dominated species belong to the Dictyoptaceae, Chordiaceae and Sargassaceae, whereas at S2 and S3, the most dominated species belong to the family Sphacelariaceae and Acinetosporaceae.
Also, Table 1 presents the newly 11 taxa of brown algal species found in the Essaouira coastline, which belong to 4 orders and 6 different families.

Table 1. Checklist in taxonomic order, of the brown algal species reported in Essaouira coastline with their Recovery Index (+ to 5) and Ecological State Groups (ESG)

Taxa	S1	S2	S3	ESG
Class Phaeophyceae				
SS Class Dictyotophycidae				
Order Dictyotales				
Family Dictoyoptaceae				
Dictyopteris lucida M.A.RiberaSiguán, A.GómezGarreta, Pérez Ruzafa, Barceló Martí & RullLluch	$+_S$			IIA
Dictyopteris polypodioides (A.P.De Candolle) J.V.Lamouroux	2_S		$+_S$	IIA
**Dictyota bartayresiana* J.V.Lamouroux	$+_S$			IIA
Dictyota dichotoma (Hudson) J.V.Lamouroux	2_{SI}		$+_S$	IIA
Dictyota dichotoma var. intricata (C.Agardh) Greville	1_S			IIA
**Dictyota fasciola* (Roth) J.V.Lamouroux	$+_I$			IIA
Dictyota implexa (Desfontaines) J.V.Lamouroux	1_S			IIA
Dictyota spiralis Montagne	1_S			IIA
Padina pavonica (Linnaeus) Thivy in W.R.Taylor	$+_I$	$+_I$	$+_I$	IB
Spatoglossum solieri (Chauvin ex Montagne) Kützing	$+_I$			IA
Taonia atomaria (Woodward) J.Agardh	1_I			IB
Order Sphacelariales				
Family Cladostephaceae				
**Cladostephus hirsutus* (Linnaeus) Boudouresque & M.Perret-Boudouresque ex Heesch & al.	1_S			IIA
Cladostephus spongiosus (Hudson) C.Agardh	2_{SI}	2_S		IIA
Family Lithodermataceae				
Pseudolithoderma adriaticum (Hauck) Verlaque	1_{SI}			IC
Family Sphacelariaceae				
Sphacelaria brachygonia Montagne	$+_I$		$+_S$	IIA
Sphacelaria cirrosa (Roth) C.Agardh			$+_S$	IIA
Sphacelaria fusca (Hudson) S.F.Gray	$+_S$	$+_I$	$+_I$	IIA
Sphacelaria plumula Zanardini	1_S			IIA
Sphacelaria rigidula Kützing			$+_I$	IIA
Family Stypocaulaceae				
Halopteris filicina (Grateloup) Kützing	1_S			IIA
Halopteris scoparia (Linnaeus) Sauvageau	2_{SI}		$+_S$	IIA

SS. Class Fucophycidae				
Order Desmarestiales				
Family Arthrocladiaceae				
Arthrocladia villosa (Hudson) Duby	$+_S$			NF
Family Demarestiaceae				
**Desmarestia aculeata* (Linnaeus) J.V.Lamouroux	$+_S$			IIB
Desmarestia ligulata (Stackhouse) J.V.Lamouroux	1_S	$+_S$	$+_S$	IIB
Order Ectocarpales				
Family Acinetosporaceae				
Acinetospora crinita (Carmichael) Sauvageau	$+_S$		1_S	IIB
Feldmannia lebelii (Areschoug ex P.Crouan & H.Crouan) Hamel	$+_I$	$+_I$		IIB
Feldmannia mitchelliae (Harvey) H.-S.Kim		$+_S$		IIB
**Hincksia granulosa* (Smith) P.C.Silva in P.C.Silva, E.G.Meñez & R.L.Moe	$+_S$	1_S	$+_S$	IIB
Hincksia hincksiae (Harvey) P.C.Silva in P.C.Silva, E.G.Meñez & R.L.Moe E		2_S	1_S	IIB
Pylaiella littoralis (Linnaeus) Kjellman (as 'Pilayella')		1_S	$+_S$	IIB
Family Chordariaceae				
Asperococcus bullosus J.V.Lamouroux	$+_S$			IB
Asperococcus ensiformis (Delle Chiaje) M.J.Wynne	$+_S$			IB
**Asperococcus fistulosus* (Hudson) W.J.Hooker	$+_S$			IB
**Elachista flaccida* (Dillwyn) Fries	$+_S$			IIB
Elachista fucicola (Velley) Areschoug		$+_S$	$+_S$	IIB
**Leathesia marina* (Lyngbye) Decaisne	$+_S$			IA
Litosiphon laminariae (Lyngbye) Harvey	$+_S$	$+_S$		IIB
**Myrionema strangulans* Greville	1_{SI}		$+_S$	IIB
Family Ectocarpaceae				
Ectocarpus fasciculatus Harvey	$+_S$	$+_S$		IIB
Ectocarpus siliculosus (Dillwyn) Lyngbye	$+_S$			IIB
Family Scytosiphonaceae				
Colpomenia sinuosa (Mertens ex Roth) Derbès & Solier in Castagne	$+_I$			IIA
Petalonia fascia (O.F.Müller) Kuntze		$+_I$	1_I	IIB
Scytosiphon lomentaria (Lyngbye) Link	$+_I$			IIB
Order Fucales				
Family Fucaceae				
Fucus spiralis Linnaeus	2_I		3_I	IB
Fucus vesiculosus Linnaeus	1_I			IB
Family Sargassaceae				
Bifurcaria bifurcata R.Ross	4_{IS}		1_{IS}	IB
Cystoseira compressa (Esper) Gerloff & Nizamuddin	$+_S$		$+_S$	IB
Cystoseira foeniculacea (Linnaeus) Greville	$+_S$			IA
Cystoseira humilis Schousboe ex Kützing			1_S	IA
Cystoseira humilis var. myriophylloides (Sauvageau) J.H.Price &	$+_I$	$+_I$	$+_I$	IA

D.M.John in J.H.Price, D.M.John & G.W.Lawson				
Ericaria crinita (Duby) Molinari & Guiry	$+_I$			IA
Ericaria mediterranea (Sauvageau) Molinari & Guiry	$+_S$			IA
Ericaria selaginoides (Linnaeus) Molinari & Guiry	3_S	$+_S$	1_S	IA
**Gongolaria abies-marina* (S.G.Gmelin) Kuntze	$+_S$			IA
Gongolaria baccata (S.G.Gmelin) Molinari & Guiry	$+_S$			IA
Gongolaria barbata (Stackhouse) Kuntze	$+_S$			IB
Gongolaria elegans (Sauvageau) Molinari & Guiry	2_S		$+_S$	IA
Gongolaria nodicaulis (Withering) Molinari & Guiry	$+_I$			IA
Gongolaria sauvageauana (Hamel) Molinari & Guiry	$+_I$			IA
**Halidrys siliquosa* (Linnaeus) Lyngbye	$+_S$			IB
Sargassum acinarium (Linnaeus) Setchell	1_S			IB
Sargassum megalophyllum Montagne	$+_S$			IB
Sargassum vulgare C.Agardh	$+_S$			IB
Order Laminariales				
Family Laminariaceae				
Laminaria hyperborea (Gunnerus) Foslie			1_S	IB
Laminaria ochroleuca Bachelot Pylaie			2_S	IB
Order Nemodermatales				
Family Nemodermataceae				
Nemoderma tingitanum Schousboe ex Bornet	1_I			NF
Order Ralfasiales				
Family Hapalospongidiaceae				
Hapalospongidion macrocarpum (Feldmann) León-Álvarez & González-González	1_S			NF
Family Pseudoralfsiaceae				
Pseudoralfsia verrucosa (Areschoug) Parente, Fletcher & G.W.Saunders			$+_S$	IC
Order Scytothamnales				
Family Bachelotiaceae				
Bachelotia antillarum (Grunow) Gerloff	$+_I$	1_I		NF
Order Tilopteridales				
Family Cutleriaceae				
Cutleria multifida (Turner) Greville	1_S			IB
Family Phyllariaceae				
Phyllariopsis brevipes (C.Agardh) E.C.Henry & G.R.South		$+_S$		NF
Phyllariopsis purpurascens (C.Agardh) E.C.Henry & G.R.South	$+_S$		$+_S$	NF
Saccorhiza polyschides (Lightfoot) Batters	4_S	2_S	3_S	IB
Total : 73	**61**	**18**	**28**	

IA, IB, IC = sensitive taxa, IIA, IIB = tolerant-opportunist taxa, NF: not found, I: Intertidal, S: upper Subtidal.

From the data included in Table 1, the global Recovery Index (RI) of the brown algal species reported in Essaouira coastline as well as their Ecological Status Groups (ESG) was analyzed. In

this sense, the high RI is attributed mainly to the Fucales and Ectocarpales. In the case of the ESG analysis, it is interesting to point out that the percentage of sensitive taxa are higher at S1 (51%), in comparison to the others sites S2 (7%) and S3 (21%).

4. Discussion

Morocco spans from the Mediterranean Sea and Atlantic Ocean. This geographical position confers to the country a remarkable variety of bioclimates, which corresponds to a great biological diversity. Several studies carried out in Morocco have emphasized this biodiversity, especially from the algal perspective. In the first report of seaweeds from Essaouira done by Bornet (1892) [1], only 1 taxon of Pheophyceae were listed. Later, Gayral (1957) [12] inventoried only 6 taxa from Mogador Island, while in this century, Benhissoune et al. (2002) [6] listed 26 taxa for the same coastal area then updated the checklist of Essaouira coastline where he found 36 brown seaweeds in 2002 [10]. In this study about the marine flora of the Essaouira coast, we have found almost twice the number of species in comparison to previous studies (Table 2). This may be due, on the one hand, to the sampling strategy adopted that aims to collect more algal species, especially in the high and middle levels. On the other hand, it could be explained by the larger number of coastal sites sampled and to the length of the seasonal investigation during two consecutive years. Indeed, a study conducted only in S1 and S2 during one season (spring) in 2016 reported only 11 brown algal species [30]. Moreover, the major differences encountered in macroalgal species richness when comparing the marine flora of the Essaouira coast with other coastal areas of Morocco and elsewhere seem to be mainly influenced by differences in research efforts [6,31–35]. Thus, the extended sampling efforts during more than two years and covering several seasons seem to promote a better understanding of the extant local marine flora and its dynamics with a larger number of reported seaweeds from a certain coastal area. While some authors have mentioned the effect of seasonal variation of algal composition in freshwater and marine ecosystems [36–39]. Based on our results, very high recruitment of macroalgal species occurs in the spring and summer months; a number of authors have reported similar results [37,40,41]. In contrast, these results differ from other published studies, such as Qari (2017) [39], who reported higher specific richness and biomass during winter due to low temperature of air and seawater with low intensity of light and higher dissolved nutrients on the Pakistan coastline.

Table 2. Number of brown seaweeds records in Essaouira region from 1892 to 2018.

Year	Number of species	References
1892	1	[1]
1897	2	[2]
1929	7	[42]
1935	9	[3]
1949	18	[20]
1957	6	[12]
1962	17	[43]
2002	26	[6]

2002	36	[10]
2016	11	[30]
2017-2018	73	The present study

Diverse studies have shown that the characteristics of the substrate are important factor for the establishment of seaweeds [44,45]. The rocky substrate of the 3 coastal areas studied is an appropriate environment for the development of a great number of macroalgal species in comparison to sandy bottoms [45]. However, S2 and S3 sampling stations located in the urban areas closer to areas where domestic and some industrial wastewaters are discharged, a decrease of algal biodiversity by 18 and 28 species, respectively was noticed in comparison to S1. The disappearance of mostly perennial seaweeds including the associated or epiphytic species due to pollution impacts have been already reported worldwide [46–48] and in the study site [18]. In addition, some species known to indicate pollution impacts (e.g., *Hincksia hincksiae*) [24] were dominant at the polluted stations S2 and S3 with 2 as recovery index, whereas others known to indicate good quality of seawater (e.g., *Ericaria selaginoides*) [24] were dominant at S1. Generally, the brown algae are known by their sensitivity [49,50]. This is why the percentage of sensitive taxa are higher at the reference station S1 with 51%, in comparison to the polluted sites S2 and S3, with 7% and 21%, respectively.

According to the current nomenclature of algal species, among the 73 brown taxa identified, 62 seaweeds are cited in previous studies by other authors (Table 2), but 11 species are newly reported for the Essaouira coast (Table 1), most of them have already been found in other localities along the Atlantic coasts of Morocco, such as in El Jadida and Mohammedia cities [51,52]. However, some macroalgae already reported by other phycologists in the study area were not found during the two consecutive years (2017 and 2018). These species belong mainly to the families Chordiaceae (e.g., *Mesogloia vermiculata*, *Punctaria latifolia*, *Spermatochnus paradoxus*), Sargassaceae (e.g., *Cystoseira foeniculacea f. tenuiramosa*, *Cystoseira usneoides*, *Sargassum trichocarpum*) and Culteriaceae (*Cutleria adspersa*, *Cutleria chilosa*, *Zanardinia typus*). Some assumptions have already been made about that and are related to the diverse studied Atlantic localities. Indeed, many species have probably been found in other Atlantic coasts in the surrounding of Essaouira city, which reflects the importance of increasing the number of study sites on the Moroccan Atlantic coast. It's related also to the sensitivity of these species according to ESG, and consequently are subjected to disappear. In fact, the ecological index of these species showed that most of these species are sensitive.

Conclusion

To sum up, the results have shown that the combined effects of the sampling strategy, the enlarged research period with seasonal samplings during two consecutive years and the rocky sites nature are probably the main parameters that influence the current high taxa richness among the brown seaweeds encountered nearby Essaouira city. A number of 11 species is identified for the first time in the Essaouira region. It is evident that surveys in other unexplored areas and particularly in deeper habitats (subtidal zone) will further increase the number of seaweed taxa. In contrast, algal biodiversity is negatively affected by anthropogenic pressures, such as polluted coastal waters,

which is one of the most important direct drivers of biodiversity loss. The most sensitive macroalgae are those that disappear first. This is why the percentage of sensitive species at Bab Doukkala (S2) and at the port (S3) is lower than that at the reference site My Bouzerktoune (S1). The current study presents an updated baseline of Pheophyceae in Essaouira and the nearby coastal area, which is critical for future tailor-targeting basic and applied seaweed studies. The overall result of the present study highlights the need for increased phycological research along the Atlantic coast of Morocco.

References

1. E. Bornet, Les algues de P.-K.-A Schousboe ré- coltées au Maroc et dans la Méditerranée de 1815 à 1829 et déterminées par M. Edouard Bornet, **Mémoires la Société Nat. des Sci. Nat. mathématiques Cherbg.,** 28 (1892)165–378.
2. F. Debray, Catalogue des Algues du Maroc, d'Algérie et de Tunisie, ed., A. Jourdan, Algérie, 1897.
3. J. Gattefossé, and R.G. Werner, Catalogus algarum Marocanorum adhuc cognitorum, **Bull. la Société des Sci. Nat. Phys. du Maroc,** 15(1935) 72–107.
4. P. Gayral, Liste commentée des algues marines nouvelles pour le Maroc, reconnues depuis 1949, **Bull. la Société des Sci. Nat. Phys. du Maroc**, 41(1961) 1–17.
5. P. Gayral, Algues de la Côte Atlantique Marocaine, ed., Société des sciences naturelles et physiques du Maroc, Californie, 1958.
6. S. Benhissoune, C.F. Boudouresque, and M.A. Verlaque, Checklist of the seaweeds of the Mediterranean and Atlantic coasts of Morocco. II. Phaeophyceae, **Bot. Mar.,** 45 (2002) 217–230.
7. M.J. Navarro, and T.G. Gallardo, Aportación al conocimiento de la flora bentón ¡ ca de las costas mediterráneas africanas occidentales, **Bot. Complut.,** 15 (1989) 203–214.
8. T. Gallardo, A.G. Garreta, M.A. Ribera, M. Cormaci, G. Furnari, G. Giaccone, and C.F. Boudouresque, Check-list of Mediterranean seaweeds II. Chlorophyceae Wille s. l, **Bot. Mar.,** 36 (1993) 399–422.
9. J.A. González, and P.F. Conde, Catálogo del macrofitobentos del Mediterráneo de Marruecos, **Acta botánica Malacit.,** 19 (1994) 5–27.
10. S. Benhissoune, Guide des algues marines du Maroc, ed., Al Manar 2 Cité Dakhla, Agadir, 2020.
11. H. Riadi, and M. Kazzaz, Inventaire bibliographique des algues benthiques du littoral Marocain. I. Chlorophyceae et Phaeophyceae, **Acta botánica Malacit.,** 23 (1998) 23–41.
12. P. Gayral, Résultat d'une prospection algologique à l'île de Mogador, **C. R. Hebd. Seances Acad. Sci.,** 245 (1957) 358–360.
13. Y. Farid, M. Chennaoui, O. Assobhei, and S. Etahiri, Screening des algues marines d'Oualidia à la recherche d'activités antimicrobienne et anti inflammatoire, **Rev. Microbiol. Ind. San et Environn.,** 6 (2012)192-209.
14. N. Bahammou, O. Cherifi, H. Bouamama, K. Cherifi, T. Moubchir, and M. Bertrand, Postharvest control of gray mold of tomato using seaweed extracts, **J. Mater. Environ. Sci.,** 8 (2017) 831–836.

15. L. Fayzi, L. Askarne, O. Cherifi, E.H. Boufous, and C. Khalil, Comparative Antibacterial Activity of Some Selected Seaweed Extracts from Agadir Coastal Regions in Morocco, **Int. J. Curr. Microbiol. Appl. Sci.,** 9 (2020) 390–399.
16. Y. Boundir, M. Hasni, F. Rafik, H. Sabri, N. Bahammou, M. Cheggour, H. Achtak, and O. Cherifi, First study of the ecological status in the Atlantic coast of Morocco using the brown seaweed *Cystoseira tamariscifolia*, **Appl. Ecol. Environ. Res.,** 17 (2019) 14315–14331.
17. S. El Atouani, Z. Belattmania, A. Reani, S. Tahiri, A. Aarfane, F. Bentiss, C. Jama, R. Zrid, and B. Sabour, Brown seaweed *Sargassum muticum* as low-cost biosorbent of methylene blue, **Int. J. Environ. Res.,** 13 (2019) 131–142.
18. H. Sabri, H. Boularhbar, A. Maarouf, S. Sbahi, M. Hasni, Y. Boundir, L. Mandi, M. Kerner, F. Weinberger, and O. Cherifi, First assessment of pollution impact at Essaouira coast (Morocco) using biotic and abiotic parameters and the Red algae *Ellisolandia elongata* as potential Bioindicator of organic pollution, **Appl. Ecol. Environ. Res.,** 18 (2020) 7717–7738.
19. E. Ar Gall, and S. Connan, Echantillonnage des macroalgues Intertidal – substrats durs. **REBENT RE. BENT.,** (2004) 1–11.
20. P. Dangeard, Les algues marines de la côte occidentale du Maroc, **Le Bot.,** 34 (1949) 89–189.
21. I. Bárbara, Algasbentonicas marinas y salobres de Galicia : Iconografias y claves de identificacion, ed., Faculty of Sciences, University of A Coruña, 2009.
22. M.D. Guiry, G.M. Guiry, AlgaeBase. – World-wide electronic publication, National University of Ireland, Galway Available online: https://www.algaebase.org/search/species/.
23. J. Braun-blanquet, Grundfragen und aufgaben der pflanzensoziologie, **Vistas Bot.,** (1959) 145–171.
24. S. Orfanidis, P. Panayotidis, and K.I. Ugland, Ecological Evaluation Index continuous formula (EEI-c) application: A step forward for functional groups, the formula and reference condition values, **Mediterr. Mar. Sci.,** 12 (2011) 199–231,
25. S. Orfanidis, P. Panayotidis, and N. Stamatis, Ecological evaluation of transitional and coastal waters: A marine benthic macrophytes-based model, **Mediterr. Mar. Sci.,** 2 (2001) 45–66.
26. J.A. Juanes, X. Guinda, A. Puente, and J.A. Revilla, Macroalgae, a suitable indicator of the ecological status of coastal rocky communities in the NE Atlantic, **Ecol. Indic.,** 8 (2008) 351–359.
27. A. Sfriso, C. Facca, and P.F. Ghetti, Validation of the Macrophyte Quality Index (MaQI) set up to assess the ecological status of Italian marine transitional environments, **Hydrobiologia,** 617 (2009) 117–141,
28. A. Sfriso, and C. Facca, Ecological indices based on macroalgae and angiosperms in the Mediterranean Eco-region: An overview, in N. Stambler (Eds.), Life in the Mediterranean Sea: A look at habitat changes, **Nova Sci. Pub.,** 2011, pp. 1–20.

29. E. Taşkın, K. Tsiamis, and S. Orfanidis, Ecological quality of the Sea of Marmara (Turkey) assessed by the Marine Floristic Ecological Index (MARFEI), **J. Blacksea/Mediterranean,** 24 (2018) 97–114.
30. H. Sabri, O. Cherifi, A. Maarouf, M. Cheggour, M. Bertrand, and L. Mandi, Wastewater impact on macroalgae biodiversity in Essaouira coast (Morocco), **J. Mater. Environ. Sci.,** 8 (2017) 857–862.
31. M.C. Gil Rodríguez, and J.S.S. Hernández, Notas ficológicas acerca de la costa atlántica-marroquí. **Vieraea,** 16 (1986) 193–198.
32. P.C. Silva, P.W. Basson, and R.L. Moe, Catalogue of the benthic marine algae of the Indian Ocean, **Univ. Calif. Publ. Bot.,** 79 (1996) 1–1259.
33. T.V. Nguyen, N.H. Le, S.M. Lin, F. Steen, and O. De Clerck, Checklist of the marine macroalgae of Vietnam. **Bot. Mar.,** 56 (2013) 207–227.
34. T.V. Titlyanova, E.A. Titlyanov, and T.L. Kalita, Marine algal flora of Hainan Island: a comprehensive synthesis, **Coast. Ecosyst.,** 28 (2014) 28–53.
35. E.A. Titlyanov, T.A. Titlyanov, B.M. Xia, and I. Bartsch, Retrospective analysis of diversity and species composition of marine macroalgae of Hainan Island (China), **Ocean Sci. J.,** 51 (2016) 1–22.
36. S. Ghosh, S.S. Barinova, and J.P. Keshri, Diversity and seasonal variation of phytoplankton community in the Santragachi Lake, West Bengal, India, **QScience Connect,** 3 (2012)1–19,
37. B.Y. Kim, J.C. Ko, H.J. Ko, S.E. Park, H.K. Cha, and H.G. Choi, Seasonal variation in community structure of subtidal seaweeds in Jeju Island, Korea, **Korean J. Fish. Aquat. Sci.,** 46 (2013) 607–618.
38. S. Kumari, and S. Guru, Das Diversity and seasonal variation of phytoplankton community in the Ranchi Lake, Jharkhand, **Int. J. Plant Res.,** 30 (2017) 50–55.
39. R. Qari, An assessment of seaweeds diversity and distribution at the beach of Nathia Gali, Karachi, Pakistan, **J. Mar. Sci. Res. Dev.,** 7 (2017) 1–12.
40. J.C. Kang, and M.S. Kim, Seasonal variation in depth-stratified macroalgal assemblage patterns on Marado, Jeju Island, Korea, **Algae,** 27 (2012) 269–281.
41. F. Breuer, P. Janz, E. Farrelly, and P. Ebke, Seasonality of algal communities in small streams and ditches in temperate regions using delayed fluorescence, **J. Freshwater Ecol.,** 31 (2016) 393–406.
42. A. Raphélis, Algues du Maroc récoltées par M. J. Gattefossé, **Bull. la Soc. Bot. Fr.,**76 (1929) 719–730.
43. R.G. Werner, Essai d'une étude de la répartition des cryptogames marines et maritimes du Maroc, **Bull. la Société des Sci. Nat. Phys. du Maroc**, 42 (1962) 1–33.
44. S.M. Coelho, J.W. Rijstenbil, and M.T. Brown, Impacts of anthropogenic stresses on the early development stages of seaweeds, **J. Aquat. Ecosyst. Stress Recover.,** 7 (2000) 317–333.
45. J.A. Acosta-Calderón, L.E. Mateo-Cid, and Á.C. Mendoza-González, An updated list of marine green algae (Chlorophyta, Ulvophyceae) from the biosphere reserve of Sian Ka'an, Quintana Roo, Mexico, **Checklist,** 12 (2016) 1–15.

46. I.M. Munda, The effects of organic pollution on the distribution of fucoid algae from the Istrian coast (vicinity of Rovinj), **Acta Adriat.,** 23 (1982) 329–337.
47. W. Schramm, Factors influencing seaweed responses to eutrophication: Some results from EU-project EUMAC, **J. Appl. Phycol.,** 11 (1999) 69–78.
48. D. Sava, E. Doroftei, and M. Arcuş, Ecology and distribution of macrophytic red algae from the Romanian Black Sea coast, **Bot. Serbica,** 35 (2011) 37–41.
49. T. Thibaut, S. Pinedo, X. Torras, and E. Ballesteros, Long-term decline of the populations of Fucales (*Cystoseira spp*. and *Sargassum spp*.) in the Albères coast (France, North-western Mediterranean), **Mar. Pollut. Bull.,** 50 (2005) 1472–1489.
50. M. Sales, and E. Ballesteros, Shallow Cystoseira (Fucales: Ochrophyta) assemblages thriving in sheltered areas from Menorca (NW Mediterranean): Relationships with environmental factors and anthropogenic pressures, **Estuar. Coast. Shelf Sci.,** 84 (2009) 476–482.
51. M. Ouahi, Contribution à l'étude de la végétation algale marine de la zone de Mohammedia, **Fac. Sc. Rabat, Maroc,** (1987) 111p.
52. N. Berday, Contribution à l'étude écologique du phytobenthos de la zone littorale de la région d'El Jadida, **Fac. Sc. Rabat, Maroc,** (1989) 170p.