Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 24(5): 147 – 160 (2020)
www.ejabf.journals.ekb.eg

Marine Algae in Egypt: distribution, phytochemical composition and biological uses as bioactive resources (a review)

Sayed Rashad* and Ghadir A. El-Chaghaby
Regional Center for Food and Feed, Agricultural Research Center, Giza, Egypt
*Corresponding Author: sayed_rashad79@hotmail.com

ARTICLE INFO
Article History:
Received: July 2, 2020
Accepted: July 17, 2020
Online: July 20, 2020

Keywords:
marine algae;
macroalgae;
seaweed;
coast;
Egypt;
bioactivity

ABSTRACT
Marine algae (Seaweeds) are photosynthetic organisms living in seas and oceans. They are known to have several benefits and are recognized as a source of several important bioactive compounds. In the present review, we present brief information concerning marine algae, their classification, distribution, and importance. Also, we are focusing on studies concerning marine algae collected from Egyptian coasts. The review highlights the important studies concerned by evaluating the bioactivity and chemical composition of marine algae in Egypt. The present review contains the main results of experimental studies discussing the antioxidant, antibacterial and anti-cancer activities of seaweeds. It also contains principle results for studies about the use of seaweed biomass as adsorbents for water treatment and as environmental pollution bio-monitors. The data provided in this review offer a scientific background about marine algae in Egypt that could be very helpful for researchers working in this area.

INTRODUCTION

Algae are photosynthetic organisms with a wide variety of forms ranging from unicellular to multicellular macroalgae (Çakir Arica *et al*., 2017). Marine algae contain a number of different species, which are usually divided into two classes, microalgae and macroalgae in particular. Microalgae species like phytoplankton survive suspended in the water column, while macroalgae (commonly referred to as seaweed) are plant-like organisms that range in size from a few centimeters to several meters in length (Hernández Fariñas et al., 2017). The huge kelp for instance rises from the seafloor to form massive underwater forests. Seaweeds have evolved to live in a number of environments, ranging from small tidal rock pools close to shore or living several kilometers offshore in depths of seawater capable of obtaining enough light to encourage photosynthesis (Fawcett *et al*., 2017). Algae are commonly divided into three groups based on algal body or thallus pigmentation. Marine macro algae are generally categorized into three major pigmentation groups; Phaeophyta (brown algae), Chlorophyta (green algae), and Rhodophyta (red algae) (Manzelat *et al*., 2018).

Marine macro algae are one of the most biologically active resources of nature, because they possess a wealth of bioactive compounds. Several marine macroalgaeisolated compounds have demonstrated numerous biological activities, including antibacterial activity, antioxidant ability, anti-inflammatory properties, anticoagulant activity, antiviral activity, apoptotic activity and prebiotic activity (Ibraheem *et al.*, 2017; El-din and El-ahwany, 2016; Rashad, *et al*., 2019).

Macroalgae are known to be rich source of dietary fiber, nutrients, lipids, fats, omega-3 fatty acids, essential amino acids, polysaccharides, and several vitamins. Different bioactive substances from aquatic species have been experimentally evaluated to research the biological impact of newly produced medications in detail (Hamed *et al*., 2018). Seaweeds are an outstanding source of components such as polysaccharides, tannins, flavonoids, phenolic acids, bromophenols, carotenoids, and provide a range of biological processes that express their solubility and polarity (Ganesan, *et al*., 2019; El-Chaghaby *et al.*, 2019).

Despite the conveniences of the twenty-first century, environmental issues, industrialization and their consequences have a negative impact on public wellbeing. At this stage algae lead people who struggle with many different diseases such as cardiovascular disease, obesity, diabetes, fatigue, cancer, hypertension, etc(Çakir Arica et al., 2017). This study aimed to give an overview about marine algae and the use and benefits of algae in different areas. The present work also summarizes some studies concerning the different marine algae collected from Egypt with focusing on their distribution, composition, bioactivity and applications.

Marine algae/ Seaweeds

Seaweed is a term applied to multicellular, marine algae that are large enough to be unassisted by the body. Some can grow to a length of 60 meters (Karupanan and Sutlana, 2017). Seaweeds are macroscopic marine algae, multicellular, and renewable resources. They are characterized as non-vascular plants that shape primary ocean producers and follow the "Protista" and not "Planta" kingdom. Like plants, they use chlorophyll pigment for photosynthesis, but they also produce other pigments that may be red, blue, brown or gold colored. Seaweed is a term applied to multicellular, marine algae that are large enough to be unassisted by the body. They are categorized into three specific classes based on pigmentation which absorb light from different wavelengths and gives them their distinctive green , brown or red colors (Kandale *et al*., 2011), anatomy, morphology and biochemical composition such as brown (Phaeophyta), red (Rhodophyta), and green seaweed. (Chlorophyta) (El-Said and El-Sikaily, 2013).

The Phylogenetic tree showing the polyphyletic group of seaweeds with illustrations of species belonging to green, red and brown macroalgae are presented in Figure (1) (Stiger-Pouvreau and Zubia, 2020).

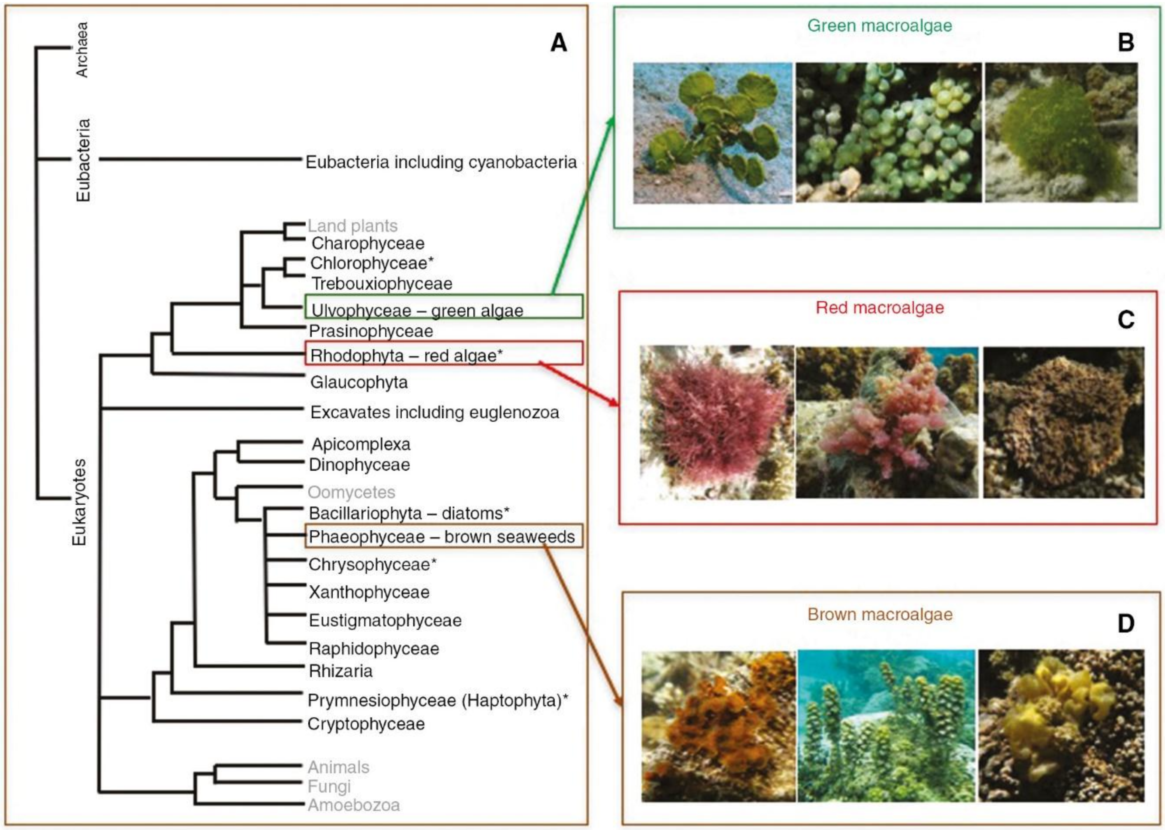

Figure (1): (A) Phylogenetic tree showing the polyphyletic group of seaweeds positioned in several lineages. (B, C, D) Illustrations of species belonging to green, red and brown macroalgae (Stiger-Pouvreau and Zubia, 2020)**.**

By fact, seaweeds are usually heterogeneous, benthic and photosynthetic species. Both the specific species of seaweeds have a commonality within the general nature of the higher green plants but they are structurally distinct from each other. Because of similarities in form and environment in underwater environments, higher aquatic species, such as salt marsh grasses and seagrasses, are classified among the marine algae. Algae are generally split into two main types, namely macroalgae and microalgae (Johnsen, 2019). The total number of algae species worldwide accounts for about 50,000 plants, about 10 % of the total plant population (Gnanavel *et al*., 2019).

Marine algae represent a wide group of species between marine organisms. According to a recent analysis, an estimated 72,500 algal species have been described worldwide, while the majority are marine (Fernando *et al*., 2016).

Macroalgae classification

The macroalgae are categorized as red (Rhodophyta), green (Chlorophyta), and brown (Ochrophyta) algae. These algae are evolutionarily distinct yet interrelated by the endosymbiotic events which gave rise to plastids. There are about 660 red algae species in the Mediterranean Sea, 180 green algae species and 280 brown algae species. Since algae have no roots, only a few species can survive on sedimentary bottoms, such as. Spp. *Caulerpa*. *Rhodophyta*'s red color stems from the dominance of pigments such as phycoerythrin and phycocyanin, which mask other pigments, e.g. *Chl a*, beta-carotene, and other xanthophylls. *Chlorophyta*'s green color derives from *Chl a* and b which masks accessory pigments, such as beta carotene and various characteristic xanthophylls (Lewis and McCourt, 2004). *Ochrophyta*'s brown color is the product of xanthophyll pigment predominance fucoxanthin, masking the other pigments, e.g. *Chl a* and c, beta-carotene, xanthophyls (van den Hoek *et al*., 1998). Long-living brown macroalgae of the *Cystoseira* genus are particularly important for the Mediterranean benthic ecosystem, since their benthic communities display a three-dimensional structure that provides habitat and shelter for smaller algae, invertebrates and fish. Degradation of benthic ecosystems is currently considered the most widespread threat to the Mediterranean's macroalgal biodiversity (Bonanno and Orlando-Bonaca, 2018).

Importance of marine algae

Marine algae have been documented to develop a large range of secondary bioactive metabolites as antimicrobial, cytotoxic agents that include alkaloids, polyketides, cyclic peptides, polysaccharides, phlorotannins, diterpenoids, sterols, quinones, glycerol-lipids. Marine macro-algae are the real sources of some strongly regulated bioactive compounds. Seaweeds provide the pharmaceutical industry with a new source of bioactive compounds in drug production (Hamed *et al.*, 2018). Many of the seaweeds have bioactive components which inhibit some of the Gram positive and Gram negative bacterial pathogens from growing. Research on the chemistry of marine algae has increased in recent years due to the need for compounds that possess bioactivities of potential pharmaceutical applications or other potential economic properties. Because marine organisms exist in an ecosystem that is drastically different from terrestrial species, it is fair to conclude that their secondary metabolites vary significantly (Morsy *et al.,* 2020).

Egyptian Coasts

Egypt's coasts extend along the Eastern Mediterranean and the Red Sea for more than 3,500 kilometers. Figure (2) shows a map for Egypt's coastal zones (AbdeL-Latif *et al*., 2012). Egypt's Mediterranean coast can be divided into four major sub-areas (Frihy and El-Sayed, 2012): The coastal field extends northwest from Sallum to Alexandria. This can be described as particularly suitable for leisure and tourism activities. Alexandria's coastal area extends further east, from Hammam to Abu Qir. Then the coastal sector of the Nile Delta extends eastwards all the way to Port Said. The easternmost region of Egypt's Mediterranean coast is the coastal region of North Sinai, which extends from Port Said to Rafah. This sector consists of large dunes which can reach considerable heights and thus protect the coastal area of course (Masria *et al*., 2014).

The Egyptian Mediterranean coast extends approximately 970 km from Rafah (Sinai Peninsula) to Salloum (east of the Libyan border), with five natural lakes extending from northern Sinai to Alexandria. (Shabaka, 2018).

The Red Sea is the northernmost tropical sea on earth. For some researchers the Red Sea coastal plain of Egypt was of great interest. The Egyptian Red Sea and Gulf of Aqaba contain an estimated 1,500 km of coral reef along the coastal and island margins, of which 800 km of fringing reef stretches from Hurghada to the Egyptian-Sudanese borders only at the east. (El-Asmar *et al*., 2015).

Figure (2): Egypt costal zones (AbdeL-Latif *et al*., 2012)

Distribution of marine algae in Egypt

Mofeed *et al*., (2015) collected macrooalgal groups throughout one year from five sites along the Suez Canal (Port Said, Qantara, Ismailia, Fayed, and Suez). The authors reported a total of 34 macroalgal species (14 *Chlorophyta*, 12 *Phaeophyta*, and 8 *Rhodophyta*). *Phaeophyta* organisms occupied the three middle sites (Qantara, Ismailia, and Faied); *Chlorophyta* had the dominance within Suez and Port Said. Meanwhile, regarding the abundance of macroalgal plants, *Chlorophyta* dominated *Phaeophyta* and *Rhodophyta* in three sites (Suez, Fayed and Port Said), where 89% of the total macroalgal vegetation was contained in Suez and 51% in Fayed, but 44% in Port Said. In the meantime *Rhodophyta* occupied the other macroalgal community at Ismailia.

El-Said and El-Sikaily, (2013) assembled several species of seaweed along Egyptian Mediterranean coast (Alexandria) during April 2011. The seaweeds were belonging to different classes including red (*Jania rubens, Gracilaria compressa, Gracilaria verrucosa, Pterocladia capillacea*, and *Hypnea musciformis*), green (*Ulva lactuca, Codium tomentosum, and Enteromorpha intestinalis*) and brown (*Colpomenia sinuosa and Sargassum linifolium*) and were collected from seven sites (Abu Qir Bay, El Montazah, Sidi Bishir, El Shatby, Eastern Harbor, El Mex Bay, and 21 km).

El-Said and El-Sikaily, (2013) reported the collection of 18 algal samples representing three algal groups over 3 years (2008–2010) a total of were collected at the beach of the tourist site "Bardiss," located at the extreme western head of Abu Qir Bay. Chlorophyceae was represented by the Ulvales order which consisted of one family:

Ulvaceae, represented by two species, *Enteromorpha compressa* (*Linnaeus) Nees* and *Ulva fasciata Delile*. The class Phaeophyceae was represented by order Dictyotales comprising the family *Dictyotaceae* represented only by the species *Padina boryana* Thivy, while the third class *Rhodophyceae* was represented by three orders (*Corallinales, Gigartinales,* and *Gelidiales*) consisting of one family each (*Corallinaceae, Hypneaceae, Pterocladiaceae*), each with one species, *Jania rubens* (Linnaeus) J. V. lamouroux, *Hypnea musciformis* (Wulfen) J. V. *lamouroux*, and *Pterocladia capillacea* (*S. G. Gemlin*) Bornet.

Pytochemical studies on "Marine algae in Egypt"

In Egypt, several researchers have focused their studies on collecting and evaluating marine algae / seaweeds in terms of their chemical and biochemical compositions, nutritional and pharmaceutical uses as well as biomass utilization. A summary of these studies is given as follows:

In October 2017, specimens from the brown seaweed *Hormophysa cuneiformis* were collected from the rocky coastal littoral zone in Hurghada region, Egypt's Red Sea coast. Specific crude polar (methanol and ethyl acetate) and non-polar (chloroform and petroleum ether) extracts of the often-untapped brown marine algae *Hormophysa cuneiformis* were tested against eight pathogenic fungi for in vitro antifungal activity. Results suggested that only possible antifungal activity demonstrated by the chloroform extract against all fungal isolates studied. The minimum inhibitory concentrations (MIC_s) ranged from 0.78 to 6.25μg.ml^{-1} and these values are very similar to those of regular amphotericin B (0.63–5μg.ml^{-1}) antifungal drug. GC – MS crude chloroform extract analysis identified 45 different bioactive compounds, including mainly 18 species of saturated, monounsaturated fatty acids and polyunsaturated fatty acids (71,48%) and essential oils. The key constituents were fatty acids arachidonic (C20:4, random–6; 16.18%), oleic (C18:1, random–9; 15.61%), palmitic (C16:0; 9.18%) and dihomo-α-linolenic (C20:3, random–6; 8.97%) (Mohamed and Saber, 2019).

Three species of algae belonging to the Phaeophyta; *Turbinaria ornata* (Turner) *J. Cystosiera myrica* (*S.G. Gmelin*) *C.Agardh* and *Padina pavonica* (Linnaeus) Thivy, were obtained from the Egyptian Red Sea at Wadi El Gemal National Park, Agardh. Antibacterial behavior of the algae extracts was tested against three pathogens. Results from the analysis indicate *T. Ornata* is a functional algae used as an antimicrobial agent in foodstuffs, pharmacology and medicinal applications (Madkour *et al*. 2019).

Six macroalgae *Caulerpa racemosa*, *Cystoseira myrica*, *Digenea simplex*, *Hormophysa cuneiformis*, *Padina pavonica* and *Sargassum cinereum* were collected and used for biomonitoring of heavy metals from three sites along the northern Red Sea coastline. *Cystoseira myrica* had the highest Fe (575.88 μg / g dry wt.) and Mn (164.12 μg / g dry wt), *Caulerpa racemosa* had the highest Cu average (91.10 μg / g dry wt), while *Sargassum cinereum* had the highest Zn and Co averages (33.88 and 16.56 μg / g dry wt.). *Padina pavonica* has had the highest Ni and Cd averages (10.46, 2.05 μg / g dry wt).(Madkour *et al*., 2019) .

Marine algae *Cystoseira barbata* from the Safaga coast was obtained at Red Sea, Egypt. The algae has been evaluated for its bioactivities and its extract has proved to have effective action against low to moderate inhibition bacterial and fungal species. Phytochemical analyzes revealed C. *Barbata* reported the highest percentage of flavonoids, phenols, and saccharides. Among the bioflavonoids found in the analysed alga were Acacetin, Kaemp.3-(2-pcomaroyl) glucose, Rosmarinic, and phenols E-Vanillic, Benzoic, and Ferulic. The results showed potential for using this alga as a source of antibacterial and antimicrobial substances (Mostafa *et al*., 2017).

During June 2009, the Red Sea Coastal Area, Hurghada, Egypt, collected the seaweeds *Sargassum dentifolium* and *Padina gymnospora* belonging to the class *Phaeophyceae*. Seaweed extracts were applied to faba bean seeds and it was shown that application of 1% aqueous extract of S. *dentifolium* or P. *gymnospora* by seed soaking was accompanied by stimulation in growth, photosynthetic pigments and the activity of antioxidant enzymes. The higher activity was observed for extract of S. *dentifolium*. In contrast, treatment with seaweed water extracts resulted in significantly decreased in MDA content, which increased under salinity stress. All the previous findings suggested the possibility that seaweed water extracts may play an important role in increasing plant resistance by stimulating the antioxidant enzyme system which associated with a marked retardation in the MDA content (Farghl *et al*., 2013).

In May 2012, *Laurencia obtusa* was collected from shallow water adjacent to the Red Sea shore of Safaga and *Corallina elongata* and *Jania rubens* were collected from shallow water adjacent to the Meditrenean Sea shore at the Egyptian Abou Quair peninsula. These three types of red marine algae were evaluated as biofertilizers for corn (*Zea mays* L.) plants. The results of the study indicated that application of single algae or their mixtures as biofertilizers resulted in an increase in parameters of plant production. (Safinaz and Ragaa, 2013).

Algal samples of *Halimeda fish*, *Padina gymnospora* and *Phacelocarpus tristichus* have been obtained from Quseir and Marsa Alam in Algae for their chemical composition and pharmacological properties at the Red Sea shores in Egypt (2016-2017). *P. gymnospora* showed optimum antibacterial activity to *E. Coli* (13.90±0.66 mm), followed by *P. tristichus* (12.97±0.65 mm), and *H. tuna* greatly inhibited the development of *S. Aureus* (0.67 mm ± 13.17). In addition, *P. gymnospora* obtained the highest antifungal activity, followed by *P. tristichus* and finally, *H. Tuna* over *C. Neoformas*, *A. Fumigate* and *P. gymnospora* also exhibited more cytotoxicity to the cell lines HepG-2 and MCF-7 than *P. tristichus* and *H. Thunfisch*. This study is one of the first studies on the chemical composition, antimicrobial activity and cytotoxicity of *P. tristichus* and this work also revealed new data on the cytotoxicity of *P. gymnospora* and *H. Tunas* on new line of cell (Abdelrheem *et al*., 2012).

Salem, *et al*., (2011) collected eight distinct algae Phaeophyaceae (*Cystoesira myrica*, *Cystoesira trinodis*, *Padina gymnospora*, *Sargassum dentifolium* and *Sargassum hystrix*); Rhodophaceae (*Actinotrichia frag*ilis) and Chlorophyceae (*Caulerpa racemosa* and *Codium fragile*) from Red Sea at Hurghada, Egypt during June 2009. Different solvent extracts of these algae were prepared. The seaweed extracts have been tested both against Gram positive and Gram negative bacteria for their antibacterial activities. Ethyl acetate extracts of C. *racemosa*, C. *fragile* and P. *gymnospora*; methanolic extracts of P. *gymnospora* and C. *fragile* showed higher antibacterial activities than other members of the tested algae.

A study has tested extracts of ethanol, methanol, ethyl acetate, hexane, chloroform, and acetone from five species of green and red algae from Abu-Qir Bay, Alexandria, Egypt for their antimicrobial , antioxidant, and cytotototoxicity activities against four cell lines. The chloroform extracts *Ulva lactuca* and *Ulva fasciata* exhibited the highest zones of inhibition against the pathogenic bacteria being tested. The extracts of *U. Lactuca* and *U. Fasciata* displayed the highest antioxidant activity (IC50 6.32±0.29mg / ml and 6.61±0.27mg / ml), using DPPH (2, 2- diphenyl-1- picrylhydrazyl) scavenging method and total antioxidant ability assay (2.13 and 1.51 mg ascorbic acid equivalent / gram dry weight, respectively). Checking for cytotoxicity using MTT assay revealed *U. lactuca* extract had a good activity against cell lines MCF-7 and Hela (IC50 10.83±1.0, 12.43±1.3µg / ml , respectively), and *U. Fasciata* displayed good activity against cell lines PC3 and HepG2 (IC50 12.99±1.2, 16.75±1.5µg / ml, respectively). The most active antimicrobial fractions in *U.*, as determined by Ultraviolet spectra, Fourier Transform Infrared Spectra, and Mass Spectroscopy of Gas Chromatography after column chromatographic purification. *Lactuca, U. Fasciata* extracts contain an aromatic compound with various active groups (-C = O, phenyl ring and -OH); di-isoctyl phthalate molecular weight is equivalent to 390,56g / mol and not limited to 390,56g / mol, respectively (Saeed *et al*., 2020).

Three species of Marine Algae *Ulva lactuca (U. lactuca), Pterocladia capillacea* (*P. capillacea*) and Jania rubens (J. rubens) extracts with LC50 values 121, 111.3 and 127 ppm respectively were evaluated to pick the most effective molluscicides to regulate *Lymnaea natalensis* (*L. natalensis*) against fascioliasis The protein content for L. *natalensis* snail tissues after treatment with U. *lactuca*, P. *capillacea* and J. *rubens* extracts was 243.6± 0.03. 196.6 ± 0.03 and 280.3 ± 0.05 µg/ml respectively and there was a significant decrease in protein contents of the treated snail tissues than controlled ones. The electrophoretic separation of snail tissues treated with mentioned algal extracts using Gel Electrophoresis, revealed several bands for each algal extract ranged from 21 to 205 kDa. The alteration in electrophoretic profile of treated snails includes appearance of new protein bands, disappearance of bands and change in the concentrations of shared bands with control snails. Based on these alterations, it was concluded that the algal extracts have molluscicidal effect on L. n*atalensis* snails (Abdel-rahman *et al*., 2020).

Four separate marine algae species; two species belonging to the Chlorophyceae (green algae) family; *Ulva lactuca* and *Enteromorpha intestinalis* and two species belonging to the Rhodophyceae (red algae) family; *Pterocladia capillacea* and *Jania rubens* have been collected from exposed rocky sites along the west edge of Abou-Qir Bay, Alexandria, Egypt. Aqueous and ethanol extracts from the four different marine algae species have been prepared and tested for their lethal effect on the *snail Lymnaea natalensis* (*L. natalensis*), the intermediate host of the trematode parasite; *Fasciola gigantica*, (F. gigantica). The most potent extracts by calculating LC50 were P. *capillacaea* and J. *rubens* aqueous extract (red algae); 111.3 and 127 ppm respectively and U. *lactuca* ethanolic extract (green algae) 121 ppm. This work announced marine algae to exert promising molluscicidal activity on L. *natalensis* snail. Also, aqueous extracts of P. *capillacaea* and J. *rubens* as well as U. *lactuca* ethanolic extract were found to be most potent and highly significant ones in the net reproductive rate and reduction (Saad *et al*., 2019).

Marine algae from the Alexandrian region's Egyptian Mediterranean Sea coast were collected at Abu Quir, Sheraton, Stanly, El-Shatby, Eastern Harbor and Agamy. The results indicated high concentrations of the important minerals such as Na , K, Ca and Mg. Brown algae have received high Na and K values followed by red and green algae.

Thus, Ca and Mg were distributed in red algae followed by large concentrations of brown and green algae. On the other hand, the basic trace elements (Fe, Cu, Zn and Mn) followed as Fe > Mn > Zn > Cu. The estimated algae content (carbohydrates and proteins) recorded in the three types of algae revealed that carbohydrate content was in the order: red algae > green algae > brown algae,. Meanwhile the protein concentration followed as red algae > brunette > green algae (Salem *et al*., 2018).

In October 2016 six types of seaweed were collected from Abu Qir on the Egyptian Mediterranean Sea coast in rocky Abu Qir Bay, Egypt. For the different species of seaweed, the biochemical constituents and key elements were determined. The moisture level ranged from 30.26 percent in *Corallina mediterranea* to 77.57 percent in *Padina boryana*. The ash content in *Sargassum wightii* ranged from 25.53 per cent in *Jania rubens* to 88.84 per cent. *Enteromorpha linza* reported the highest concentrations of lipids and carbohydrates. The *Mediterranean* had the lowest lipid content (0.5%), and the carbohydrate content (38.12%) Brown species held the largest number of elements followed by red and green seaweeds. All tested seaweed extracts except *Ulva lactuca* were observed with high reducing power capacity (Ismail *et al*., 2017).

Six algae (*Sargassum dentifolium, Padina boryana, Dictyota dichotoma, Gelidium latifolium, Gracilaria dura, and Enteromorpha intestinalis*) were collected from marine (euhalopic) ecosystems in Alexandria, Hurghada, Fayed, Egypt. Some biochemical comparative work between the freshwater algae and the six marine algae was performed to determine how marine algae would cope with salinity in seawater. Results obtained showed that fluorescence peaks within the same class for the species being examined were relatively uniform, but varied for different classes or divisions. The protein profile studied revealed the presence of only three common protein bands (125, 15 and 8 kDa) in the euhalopic algal group, and finally, only one common protein band (240 kDa) in all oligohalopic algae members. The amount of proline showed peculiar differences under investigation between the marine and the fresh algae. Mannitol is found only in brown algae. Furthermore, the level of marine algae in minerals (sodium and potassium) and glycerol is substantially higher than in fresh algae. Glycerol-3-phosphate dehydrogenase (G3PDH) has had a significant effect on biosynthesis of glycerol. In this analysis, we analyze the differential expression of marine algal group (G3PDH) compared to that of freshwater group one. Results indicated that the expression level of (G3PDH) mRNA was significantly higher in marine algal groups (Mansour and Emmam, 2017).

Pterocladia capillace (c. Agardh) a genus of red macro-algae and *Ulva lactuca* linneals (Gmel) Born a genus of green macro-algae were collected from the Mediterranean Sea Shore of Alexandria in 2014. The two marine macro-algae were tested for elimination of chloramphenicol, clofibric acid, acetyl salicylic acid, nonylphenol, and bisphenol in aqueous solutions. Results showed that chlorophyll "a" content of both algal biomasses decreased with rising pharmaceutical concentrations. The findings showed that the maximum biosorption of pharmaceutical and endocrine disruptor compounds in nonylphenol > acetyl salicylic acid > clofibric acid > bisphenol > chloramphenicol was recorded for Pterocladia capillacea, while the maximum biosorption of Ulva lactuca was observed for acetyl salicylic acid > bisphenol > nonylphenol > chloramphenicol at 12 hours contact period. All the algae examined suffered oxidative stress due to antibiotic exposure and endocrine disruptor compounds. The research results indicated an increase in the levels of the antioxidant enzymes superoxide dismutase (SOD), ascorbate peroxidase (APO), catalase (CAT) in the algae studied following exposure to various pharmaceuticals in relation to their control activities (Mohy El.Din *et al*., 2017).

Ulva samples were collected from two stations, Ras Al-Tin (station A) and El-Muntazah (station B) along the coast of Alexandria in the Mediterranean Sea, in 12 sampling periods (January to December 2012). At each station, each three samples were plotted to reflect a single season. The chemical characterization of the lipid fractions was done and results showed that *Ulva* lipid content is relatively high (9.4±1.5 and 12.2±2.7 percent DW, respectively at stations A and B), which can be explained by station A's higher emission level. Monounsaturated fatty acids (MUFAs) accounted for 17.6-33.4 percent of the TFAs. High percentage of polyunsaturated fatty acids (PUFAs) occurred in *Ulva* extraction, reaching a high in both winter and spring stations, at stations A and B around 38.4 and 30.5 percent of TFAs respectively (Moustafa and Batran, 2014).

From the Abu Qir, Alexandria, three marine cyanobacteria *Oscillatoria simplicissima*, *Oscillatoria acutissima,* and *Spirulina platensis* were collected. Their antimicrobial activities have been tested. Results showed that the three-algal methanol extract was very effective against bacterial and fungal strains in comparison with other extracts at pH 8.0, 30^{o}C and 3000 lux. No antimicrobial activity was found in the water extracts. This material was developed for *Oscillatoria simplicissima, Spirulina sp.* and *Oscillatoria acutissima*. Incubation time 12, 14, 12 days. The results indicated potential for the use of these microalgae as an antimicrobial source (Ismael and Halim, 2012).

The *Pterocladia capillacea* Red Marine macroalgae had been collected from Abo-Quir Bay, Alexandria, Egypt. The macroalgae biomass was used for activated carbon manufacturing to eliminate poisonous hexavalent chromium from the aqueous solution. The report demonstrated that the activated carbon derived from the red alga *P. capillacea* can be used as a promising activated carbon to remove toxic chromium from synthetic sea water , natural sea water and wastewater (El Nemr *et al*., 2011).

CONCLUSION

The present work gives a brief review concerning marine algae with special reference to marine algae in Egypt. The review documents the distribution of marine algae along the Egyptian coasts. After summarizing the studies investigating uses and composition of marine algae in Egypt, it can be affirmed that macroalgae are important sources of natural components extraction. These algae can be collected and widely used in Egypt and other countries in nutrition and therapy and the biomass could be valorized to produce adsorbents in water treatment filters or as source of biofuel.

REFERENCES

AbdeL-Latif, T.; Ramadan, S.T. and Galal, A.M. (2012). Egyptian coastal regions development through economic diversity for its coastal cities. HBRC J. 8, 252–262. https://doi.org/10.1016/j.hbrcj.2012.10.009

Abdel-rahman, E.H.; Saad, A.E.A. and Hassanain, M.A. (2020). Electrophoretic profile of treated Lymnaea natalensis snails with Pterocladia capillacea , Jania rubens and Ulva lactuca algal extracts 24: 443–451.

Abdelrheem, D.A.; Rahman, A.A.; Elsayed, K.N.M.and Ahmed, S.A. (2020). GC/MS spectroscopic approach, antimicrobial activity and cytotoxicity of some marine macroalgae from Qusier and Marsa Alam Seashore (Red Sea), Egypt. Egypt. J. Aquat. Biol. Fish. 434: 138–142.

Bonanno, G. and Orlando-Bonaca, M. (2018). Trace elements in Mediterranean seagrasses and macroalgae. A review. Sci. Total Environ. 618: 1152–1159. https://doi.org/10.1016/j.scitotenv.2017.09.192

Çakir Arica, Ş.; Ozyilmaz, A.; Demirci, S. and Şükran Çakir Arica, C. (2017). A study on the rich compounds and potential benefits of algae: A review. Pharma Innov. J. 6, 42–51.

El-Asmar, H. M.; El-Kafrawy, A. M. H.; Oubid-Allah, S. B.; Mohamed, A.H. T. A. and Khaled M.. A. (2015). Monitoring and assessing the coastal ecosystem at Hurghada, Red Sea coast, Egypt. J. Environ. Earth Sci. 5: 144–160.

El-Chaghaby, G.A.; Rashad, S.; Abdel-Kader, S.F.; Rawash, E.-S.A. and Moneem, M.A., (2019). Assessment of phytochemical components, proximate composition and antioxidant properties of Scenedesmus obliquus, Chlorella vulgaris and Spirulina platensis algae extracts. Egyptian Journal of Aquatic Biology & Fisheries, 23(4): 521 – 526.

El-din, S.M.M. and El-ahwany, A.M.D. (2016). Bioactivity and phytochemical constituents of marine red seaweeds (Jania rubens , Corallina mediterranea and Pterocladia capillacea). Integr. Med. Res. 10: 471–484. https://doi.org/10.1016/j.jtusci.2015.06.004

El-Said, G.F. and El-Sikaily, A. (2013). Chemical composition of some seaweed from Mediterranean Sea coast, Egypt. Environ. Monit. Assess. 185: 6089–6099. https://doi.org/10.1007/s10661-012-3009-y

El Nemr, A.; El-Sikaily, A.; Khaled, A. and Abdelwahab, O. (2011). Removal of toxic chromium from aqueous solution, wastewater and saline water by marine red alga Pterocladia capillacea and its activated carbon. Arab. J. Chem 8: 105–117. https://doi.org/10.1016/j.arabjc.2011.01.016

Farghl, A.A.M.; Galal, H.R. and Hassan, A., (2013). Influence of Seaweed Extracts (Sargassum dentifolium or Padina gymnospora) on the Growth and Physiological Activities of Faba Bean and Wheat Plants Under Salt Stress. Egypt. J. Bot. 54: 121–135. https://doi.org/10.21608/ejbo.2013.483

Fawcett, D.; Verduin, J.J.; Shah, M.; Sharma, S.B. and Poinern, G.E.J. (2017). A Review of Current Research into the Biogenic Synthesis of Metal and Metal Oxide Nanoparticles via Marine Algae and Seagrasses. J. Nanosci, 1–15. https://doi.org/10.1155/2017/8013850

Fernando, I.P.S.; Nah, J.W. and Jeon, Y.J. (2016). Potential anti-inflammatory natural products from marine algae. Environ. Toxicol. Pharmacol. 48: 22–30. https://doi.org/10.1016/j.etap.2016.09.023

Frihy, O.E. and El-Sayed, M.K. (2012). Vulnerability risk assessment and adaptation to climate change induced sea level rise along the Mediterranean coast of Egypt. Mitig. Adapt. Strateg. Glob. Chang., 1–23.

Ganesan, A.R.; Tiwari, U. and Rajauria, G. (2019). Seaweed nutraceuticals and their therapeutic role in disease prevention. Food Sci. Hum. Wellness 8, 252–263. https://doi.org/10.1016/j.fshw.2019.08.001

Gnanavel, V.;Roopan, S.M. and Rajeshkumar, S. (2019). Aquaculture: An overview of chemical ecology of seaweeds (food species) in natural products. Aquaculture 507: 1–6. https://doi.org/10.1016/j.aquaculture.2019.04.004

Hamed, S.M.; Abd El-Rhman, A.A.; Abdel-Raouf, N. and Ibraheem, I.B.M. (2018). Role of marine macroalgae in plant protection & improvement for sustainable agriculture technology. Beni-Suef Univ. J. Basic Appl. Sci. 7: 104–110. https://doi.org/10.1016/j.bjbas.2017.08.002

Hernández Fariñas, T.; Ribeiro, L.; Soudant, D.; Belin, C.; Bacher, C.; Lampert, L. and Barillé, L., (2017). Contribution of benthic microalgae to the temporal variation in phytoplankton assemblages in a macrotidal system. J. Phycol. 53: 1020–1034. https://doi.org/10.1111/jpy.12564

Ibraheem, I.B.M.; Elaziz, B.E.A.; Moawad, A.; Hassan, H.M.; Mohamed, W.A.; Abdel-raouf, N. (2017). Antimicrobial and Anti-inflammatory Effects of Two Different Marine Red Algae Species Collected from 2: 1–10. https://doi.org/10.9734/AJOB/2017/32964

Ismael, A. and Halim, Y. (2012). Potentially harmful Ostreopsis spp . in the coastal waters of Alexandria - Egypt 208–212.

Ismail, M.M.; El Zokm, G.M. and El-Sayed, A.A.M. (2017). Variation in biochemical constituents and master elements in common seaweeds from Alexandria Coast, Egypt, with special reference to their antioxidant activity and potential food uses: prospective equations. Environ. Monit. Assess. 189. https://doi.org/10.1007/s10661-017-6366-8

Johnsen, U.H. (2019). The benthic algae of the Bærum basin in the inner Oslofjord. A comparison of eight sites between 1993-94 and 2018(Master's thesis).

Kandale, A.; Meena, a K.; Rao, M.M.; Panda, P.; Mangal, a K.; Reddy, G. and Babu, R. (2011). Marine Algae: An Introduction, Food Value and Medicinal Uses. J. Pharm. Res. 4: 219–221.

Karupanan, S. and Sutlana, M. (2017). an Overview on Gracilaria Follifera. Indo Am. J. Pharm. Res. 7.

Madkour, A.G.; Rashedey, S.H. and Dar, M.A. (2019). Spatial and temporal variations of heavy metals accumulation in some macroalgal flora of the Red Sea. Egyptian Journal of Aquatic Biology & Fisheries, Egypt 23: 539–549.

Madkour, F.F.; El-Shoubaky, G.A. and Ebada, M.A. (2019). Antibacterial activity of some seaweeds from the red sea coast of Egypt. Egypt. J. Aquat. Biol. Fish. 23: 265–274. https://doi.org/10.21608/ejabf.2019.31016

Mansour, H. and Emmam, M. (2017). Gene Over-Expression of Glycerol-3-phosphate Dehydrogenase in Some Marine Algae of Egypt. Egypt. J. Bot. 57: (1) 31- 48 https://doi.org/10.21608/ejbo.2017.977

Manzelat, F.S.; Mohammed Mufarrah, A.; Ahmed Hasan, B.; Ali Hussain, N.; Shuqaiq, A.; Huraidha, A.; Qahma, A. and Birk, A. (2018). Macro algae of the Red Sea from Jizan , Saudi Arabia. Phykos, 48: 88–108. https://doi.org/10.13140/RG.2.2.33707.69920

Masria, A.; Negm, A.; Iskander, M. and Saavedra, O. (2014). Coastal zone issues: A case study (Egypt). Procedia Eng. 70: 1102–1111. https://doi.org/10.1016/j.proeng.2014.02.122

Mofeed, J.; Deyab, M.A.; Damietta, N. and Canal, S. (2015). Monitoring for the abundance and distribution of macroalgae along Suez Canal, Egypt, 1 11: 81–91.

Mohamed, S.S. and Saber, A.A. (2019). Antifungal potential of the bioactive constituents in extracts of the mostly untapped brown seaweed hormophysa cuneiformis from the Egyptian coastal waters. Egypt. J. Bot. 59: 695–708. https://doi.org/10.21608/ejbo.2019.5516.1225

Mohy El.Din, S.; Noaman, N. and Zaky, S. (2017). Removal of Some Pharmaceuticals and Endocrine Disrupting Compounds by the Marine Macroalgae Pterocladia capillacea and Ulva lactuca. Egypt. J. Bot. 57(1): 139 - 155. https://doi.org/10.21608/ejbo.2017.350.1009

Morsy, G.M.T.; Bekhet, E.K. and Mohamed, E.A. (2020). Phytochemical screening for antibacterial compounds of some seaweed from coastal area of abu-qir , alexandria , egypt phytochemical screening for antibacterial compounds of some seaweed from coastal area of abu-qir , alexandria. Egyptian J. of Phycol., 19: 47-57.

Mostafa, A. Y.T. and Batran, A.M.M. (2014). Lipid chemistry of green macroalgae Ulva sp. a potential resource for biotechnological applications in the Southern Mediterranean Sea Coast, Alexandria shore, Egypt. Egypt. J. Aquat. Biol. Fish., Vol. 18: 9–20

Mostafa, S.; Samah, S.; Mohamed, H.; Ibraheem, I. and Abdel-Raouf, N. (2017). Controlling of Microbial Growth by Using Cystoseira barbata Extract. Egypt. J. Bot. 469–477. https://doi.org/10.21608/ejbo.2017.911.1071

Rashad, S.; El-Chaghaby, G.A.; Elchaghaby, M.A. (2019). Antibacterial activity of silver nanoparticles biosynthesized using spirulina platensis microalgae extract against oral pathogens. Egypt. J. Aquat. Biol. Fish. 23(5): 261 - 266. https://doi.org/10.21608/ejabf.2019.65907

Saad, A.E.A.; Hassanain, M.A. and Darwish, E.M. (2019). Molluscicidal effect of some red and green marine algae on Lymnaea natalensis 23: 483–490.

Saeed, A.M.; Abotaleb, S.I.; Alam, N.G.; Elmehalawy, A.A. and Gheda, S.F. (2020). In vitro assessment of antimicrobial, antioxidant and anticancer activities of some marine macroalgae. Egypt. J. Bot. 60: 81–96. https://doi.org/10.21608/ejbo.2019.11363.1303

Safinaz, A.F. and Ragaa, A.H. (2013). Effect of some red marine algae as biofertilizers on growth of maize (zea mayz l.) plants. Int. Food Res. J. 20: 1629–1632.

Salem, D. M. S. A.; El Sikaily, A. and Abou-taleb, A. E.A. (2018). Nutritional value and health quotient of algae collected from Egyptian coast, 1- 22: 419–429.

Salem, W. M. (2011). Screening for antibacterial activities in some marine algae from the red sea (Hurghada, Egypt). African J. Microbiol. Res. 5. https://doi.org/10.5897/ajmr11.390

Shabaka, S.H. (2018). Checklist of seaweeds and seagrasses of Egypt (Mediterranean Sea): A review. Egypt. J. Aquat. Res. 44: 203–212. https://doi.org/10.1016/j.ejar.2018.08.001

Stiger-Pouvreau, V. and Zubia, M.(2020). Macroalgal diversity for sustainable biotechnological development in French tropical overseas territories. Bot. Mar. 63: 17–41. https://doi.org/10.1515/bot-2019-0032