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Vegetation and Biochemical analysis of Caulerpa Racemosa from Red Sea Coast at Hurghada-Egypt

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Abstract

Caulerpa racemosa strain from Red Sea Coast (Hurghada, Egypt) was identified by its morphological characteristics. The suitable trophic status of saline water and sand sediment at the study site resulted in the massive growth of *Caulerpa racemosa*. Biochemical analysis of *C. racemosa* revealed high/moderate/lowprotein content (22.65 mg/g dry wt), relatively low soluble carbohydrate content (30.67 mg/g dry wt) but high insoluble carbohydrate content (200.47 mg/g dry wt), high/moderate/low lipid content (11.47 mg/g dry wt) and high content of K, Na, Ca and P (5.3, 43.23, 8.7 and 11.4 mg/g dry wt, respectively). *Caulerpa racemosa* contained the heavy metals Fe, Co, Cu, and Cd at concentrations of 0.43, 1.1, 0.6 and 1.3 mg/g dry wt, respectively. The qualitative analysis of natural products indicated that *Caulerpa racemosa* contains alkaloids, saponins, flavonoids, phenols and quinones.

Keywords: *Marine macroalgae; Chlorophyta; Caulerpa racemosa; Biochemical analysis.*

Introduction

Seaweeds are plant-like organisms that can be a few centimeters long or several meters long **(Hernández Fariñas *et al*., 2017).** Seaweeds can be found in a variety of habitats that range from little tidal rock pools near the beach to deep ocean depths, because they are capable of performing photosynthesis many kilometers offshore **(Fawcett *et al*., 2017)**. Seaweeds are divided into three types based on their pigmentation: brown algae (Phaeophyta/Ochrophyta), green algae (Chlorophyta), and red algae (Rhodophyta) **(Manzelat *et al*., 2018)**. Marine macroalgae are one of nature's most biologically active resources, with a multitude of bioactive chemicals, including antibacterial, antiviral and prebiotic constituents **(El-din and El-ahwany, 2016; Rashad, *et al*., 2019).** Macroalgae are also high in dietary fibers, polysaccharides, minerals, lipids, omega-3 fatty acids, essential amino acids and a variety of vitamins **(Ibraheem *et al*., 2017).** Polysaccharides, tannins, flavonoids, phenolic acids, bromophenols, and carotenoids are abundant in seaweeds, and they support a variety of biological processes that express their solubility and polarity **(Ganesan, *et al*., 2019; ElChaghaby *et al*., 2019).** Currently, algae are utilized in the treatment of a variety of ailments, including cardiovascular diseases, obesity, diabetes, cancer, hypertension, and many more **(Çakir Arica *et al*., 2017)**.

From macroalgal species, there are around 12,272 algae species categorised as chlorophyta (green algae). There are about eight species of *Caulerpa* has been reported in Egypt; that is *C. lentillifera*, *C. peltata*, *C. racemosa*, *C. scalpelliformis*, *C. serrulata*, *C. sertulariodes*, *C. taxifolia* and *C. verticillata* **(Phang *et al*., 2004 ; Penang *et al*., 2006*)*.** *Caulerpa racemosa*, often known as sea grapes, is a native delicacy served as a vegetable or salad by coastal residents in Southeast Asian nations such as Indonesia, the Philippines, and Malaysia **(Novaczek et al., 2001)**. *Caulerpa racemosa* is well-known for its great nutritional value, because of the high concentration of polyunsaturated fatty acids (PUFA), essential amino acids, minerals, dietary fibres, vitamins, and antitumor substances **(Kumar *et al*., 2011; Nagappan *et al*., 2014)**. *C. racemosa* anticancer properties are attributed to the existence of natural bioactive chemicals **(Tanna *et al*., 2018; Yap *et al*., 2019)**. The stock of *Caulerpa racemosa* (Forsskal) J. Agardh is quickly declining as a result of intensive harvesting for food and feed **(Paul *et al*., 2014).** *C. racemosa* is frequently cultured as a functional food under controlled conditions. Changes in environmental variables such as sedimentation, salinity, temperature, and pollution cause natural populations have varied traits **(Smyth *et al*., 2016)**. The nutritional and biochemical features of the earthen pond *C. racemosa* were expected to differ from natural specimens in the wild under settings where seaweed growth is dependent on nutrients from fish feed and effluent. Because there is no information on the vegetation, chemical composition, or phytochemical properties of *Caulerpa racemosa* under similar growth conditions in the literature, this study will assess the vegetation, biochemical contents, and phytochemical properties of *Caulerpa racemosa* in relation to habitat conditions.

Materials and Methods:

Study Area:

The collection site was along the shores of Hurghada, Red Sea coast, Egypt; it is the one of most important places for algae growth in Egypt. Hurghada is located on the western coast of the Red Sea at longitude 48'33 degrees east and latitude 15'27 degrees north. Administratively, it is the capital of the Red Sea governorate. It is bordered from the north by Ras Ghareb; 143 km, and Safaga from the south; 61 km. It overlooks the Red Sea coast from the east and directly the Red Sea from the west.

Figure 1: Red Sea Coast (Hurghada)-Egypt.

Aquatic habitat properties:

Water and sediment samples were collected from **Red Sea Coast (Hurghada)-Egypt** (during spring of 2019). Physicochemical analysis of water and sediment was carried out according to the procedures adopted by **Radojevic (1999) and Mussa and Hawaa (2009)**.

Collection and preparation of macroalgal materials (Caulerpa racemosa)

Caulerpa racemosa was collected from the study site during spring of 2019 in triplicate from 1 m^2-quadrate which was randomly laid down along the study site to estimate the algal cover. The collected *C. racemosa* was directly washed with seawater to remove any epiphytic organisms and debris and transported immediately to the laboratory in an ice box (-10 °C).

The morphological characteristics of *C.*

racemosa (fresh) included the thallus color, length, texture and the holdfast was screened. The microscopic investigation included characterization of thallus thickness, size, arrangement and shape of cells and arrangement of chloroplasts in surface view. Both morphological and microscopic examination aided in identification of the collected alga as *Caulerpa racemosa* according to **Kong *et al.* (2011)**.

In the laboratory, the algal samples were further cleaned up from epiphytes and non-living debris by washing with running tap water, followed by rinsing many times with distilled water to remove salts from the surface then blotted gently and weighed to estimate fresh weight. The samples were then spread on filamentous nets and allowed to dry in air and reweighed to obtain the air-dry weight. The dried material was ground into a fine powder using electric mixer and stored in polyethylene bags at room temperature for further use as recommended by **Tran *et al.* (2018).**

Algal extract

An aliquot of the dried powder (500 g) was soaked in 4 L EtOH for 3 days at room temperature. A thick green oily material was left after removal of the solvent. The oily extract was homogenized with EtOH and left overnight in an ice box where a mass of about 2 g of an orange-red precipitate was obtained.

Biochemical analysis of the extract of Caulerpa racemose :

Determination of Proteins was measured by Bradford (1976).

Determination of Total Soluble and Insoluble Carbohydrates was measured according to Schortemeyer *et al.* (1997).

Determination of lipids was investigated according to Egan *et al.* (1981).

Determination of Potassium, Sodium and Calcium Ions was determined by using method of Hawk *et al.* (1947).

Determination of Heavy Metals was investigated according to Moore and Chapman (1986).

Qualitative analysis of the natural products of Caulerpa racemosa extracts:

Savithramma *et al*. (2011) proposed a standard approach for assessing the phytochemical screening of different algal extracts.

Results and discussion:

The present study reveals that the massive growth of *Caulerpa racemosa* may be due to semi optimal physicochemical properties of saline habitat at study area. *Caulerpa racemosa* has a branching structure with stolons that are anchored to the sandy substrate by rhizoids. The branches are a few centimeters apart and can grow to a height of (7-11) cm. Numerous spherical or oval lateral buds branch off these and give the seaweed its name of sea grapes. Moreover, each *C. racemosa* plant consists of a huge cell with a large number of nuclei.

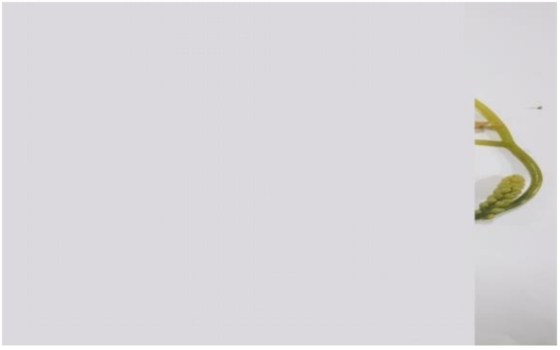

Figure 2: *Caulerpa racemosa* from Red Sea Coast at Hurghada – Egypt

The present results indicated the most physicochemical properties of water at the study site more or less in optimal limit which stimulate the massive growth of *Caulerpa racemosa.* The results also reflected that temperature was 28C□, pH (7.6) and salinity (41.61%) which stimulates the massive growth of *Caulerpa racemosa*, this result agreed with **Fletcher (1996).**

The suitable concentration of nutrients as nitrate (0.14 mg/L), orthophosphate (0.09 mg/L), and Low concentrations of total iron (0.08 mg/L) were determined especially in well-oxygenated habitats and gives the optimal trophic condition of *Caulerpa racemosa*.

Most physiochemical properties of sediment have relatively high content of nutrients as nitrogen group, phosphorous group and heavy metals more than that was recorded in the water at the same study site. This mainly due to the salts and nutrients as well as other water contents increase gradually towards bottom **(Table 1).** Since the sediment of shallow water systems may contribute significant concentrations of dissolved inorganic nitrogen and dissolved inorganic phosphorous to the overlying water to stimulate the growth of

Caulerpa racemosa, this agrees with **Human *et al.* (2015).**

Table 1: Physicochemical properties of water and sediment at the study site

Physicochemical characteristic	seawater	sediment
Temperature (˚C)	28	28
pH	7.6	7.3
Salinity (g/L)	41.61	57.2
Total alkalinity (meq/L)	2.39	
DO (mg/L)	13	8
BOD (mg/L)	3.6	4.1
COD (mg/L)	4.2	6.3
Ammonia-N (mg/L)	0.07	
Nitrite-N (mg/L)	0.03	0.2
Nitrate-N (mg/L)	0.14	2.8
Total-nitrogen (mg/L)	3.1	4.2
Total-phosphorous (mg/L)	1.9	2.5
Orthophosphate-P (mg/L)	0.09	0.5
Fe (mg/L)	0.08	0.15
Cu (mg/L)	0.06	0.13
Cd (mg/L)	0.007	0.08
Co (mg/L)	0.2	0.3

It was known that dissolved oxygen has a relatively low value at bottom than that at surface of water. This mainly due to the high biological and chemical consumption of dissolved oxygen at the bottom (sediment) through the high chemical oxygen demand (COD) and biological oxygen demand (BOD) in the same time the relative low oxygen production at the bottom. Dominance of opportunistic macroalgal species in areas undergoing eutrophication has been attributed to storage of inorganic nutrients, high growth rates and high tolerance to a wide range of temperatures and salinity, this agreed with **Aveytua-Alcázar *et al.* (2008).** Physico-chemical parameters of the Red Sea affect the composition and the structure of the existing macroalgal communities including surface water temperature, light intensity and salinity **(Osman and Mohammed 2016)**.

This massive growth of *C. racemosa* was mainly due to the sandy substratum of study site. The mean of covering vegetation was recorded (18%) in 1 m² quadrat. **Schmidt *et al.* (2013)** reported that each line transect traversed a different distance, starting in the surface and ending in the intertidal zone**.** Moreover the massive growth at the study site was 4250 fresh weight/m² and 520 g dry weight/m². The soft sandy sediment affects the rate of growth.

The relative high biochemical contents of *Caulerpa racemosa* mainly due to the relative high contents of nutrients in the sediment of the sandy substratum presented at the study site. **Rodríguez Castañeda *et al*. (2006)** conclude that *Caulerpa racemosa* chemical composition varies depending on the geographical distribution, the season and the principal environmental factors.

Table 2: Vegetation analysis of *C. racemosa*

Characteristic	
Fresh weight (g/m^2)	4250
Dry weight (g/m^2)	520
Covering (%)	18
Length (cm)	15-75
Height (cm)	7-11
covering area	100 hectare

Biochemical analysis *of C. racemosa* showed that generally the protein content was 22.65 mg/g dry wt. It was relatively low soluble carbohydrates content (30.67 mg/g dry wt) but high insoluble carbohydrates content (200.47 mg/g dry wt). Moreover, *Caulerpa racemosa* was contained 11.47 mg/g dry wt of lipids and rich in minerals contents (K, Na, Ca and P) but it has contained sodium content of 43.23 mg/g dry wt higher than the other minerals of K, Ca and P (5.3 mg/g dry wt., 8.7 mg/g dry wt. and 11.4 mg/g dry wt. respectively). *Caulerpa racemosa* has accumulated heavy metals like Fe, Co, Cu, and Cd which varied between 0.43 mg/g dry wt to 1.3 mg/g dry wt for Fe and Cd, respectively (Table 3). **Vymazal (1995)** proposed that metal accumulation is influenced by the kind of polysaccharides in algae, and since different elements have varied electronegativity (tendency to receive electrons), this could have an impact on metal uptake in algae at various levels. He attributed the variations in the metals contents in the seaweed to the different metals electronegativity (e.g. Fe, Ni and Cu). **Billah *et al*. (2017)** documented that the concentrations of heavy metals in algal tissues are varied among macroalgal species, probably due to of the differences of structure, age, and growth of thallus among macroalgal species.

C. racemosa have six natural products groups, It has natural products groups; Alkaloids, Terpenoids, Saponins, Flavonoids, Phenols and Quinones. The presence or absence of natural products groups maybe due to the remarkable variation in the physicochemical properties of water and sediments at the study site **(Table 4).**

Table 3: Biochemical analysis of *Caulerpa racemosa* extract.

Constituent (mg/g dry wt.)	
Protein	22.65
Sol.carbohydrates	30.67
Insol.carbohydrates	200.47
Lipids	11.47
K^+	5.3
Na^+	43.23
Ca^{2+}	8.7
P	11.4
Fe	0.43
Cu	0.6
Cd	1.3
Co	1.1

Table 4: Qualitative estimation of *Caulerpa racemosa* natural products.

Phytochemical parameter	
Alkaloids	+
Terpenoids	+
Tannins	-
Saponins	+
Flavanoids	+
Phenolics	+
Coumarins	-
Quinones	+
Glycosides	-

Conclusions:

Semi optimal physicochemical properties of water and sediment at study site resulted in massive growth of *Caulerpa racemosa* (18%). Biochemical analysis of *Caulerpa racemosa* revealed that very high content of carbohydrates considerable content of protein , lipid and minerals .Moreover ,the qualitative analysis of phytochemical contents of *Caulerpa racemosa* revealed that the presence of Alkaloids , Terpenoids , Saponins , Flavanoids , Phenols and Quinones.

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الملخص العربي

عنوان البحث:

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نتج عن الخواص الفيزيائية والكيميائية شبه المثلى للماء والرواسب في موقع الدراسة الى نمو هائل للكوليربا راسيموزا (١٨% غطاء نباتي) ، واظهر التحليل الكيميائي للكوليرا راسيموزا انها تحتوى على نسبة عالية جدا من الكربوهيدرات ونسبة اعتبارية من البروتين و الدهون والمعادن . علاوة على ذلك اظهر التحليل النوعى للمنتجات الطبيعية للتمثيل الغذائي الثانوي للكوليربا راسيموزا على وجود قلويدات ،تيربينويد ، صابونين، فلافونويد ، فينولات وكينونات.