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PRELIMINARY STUDIES ON IMPACT OF THERMAL POLLUTION ON ALGAL VEGETATION IN FRONT OF ELARISH POWER PLANT

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Abstract

The ecological survey of the algal vegetation at ElArish coast (~30 Km) was recorded for the first time at spring 2000. Ninety species of marine algae were identified from eight stations, extending between ElRisa (eastward) and ElZaranik (westward). Sixteen species of green algae, 4 species of brown algae, 15 species of red algae, 10 species of blue-greens and 46 species of diatoms were recorded. The power plant exerted negative effect on the nature of the surrounding area. It caused obvious corrosion of the sandy shore in front of the power plant. Warm effluents at the outlet led to complete disappearance of seaweeds however; excessive growth of the tolerant species of diatoms and blue-green algae was noticed. Twenty-nine species (24 diatoms, 5 blue-greens) had been recorded only from the cooling water station.

Key words: blue-green algae, diatoms, El-Arish power plant, Mediterranean Sea, seaweeds, thermal pollution.

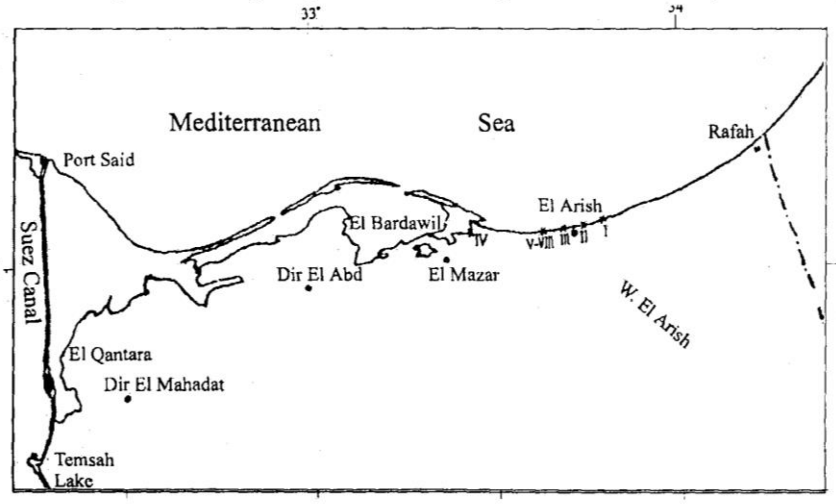
Introduction

The north of Sinai Peninsula is a large plain descending from ElTih plateau towards the Mediterranean Sea (Ghallab, 1960). The soil texture categories of Wadi ElArish encountered from heavy clayey near ElRawafaa dam to sandy at Rafah-ElArish area (Abd ElMalek *et al.,* 1971). New pavements of rocks were extended at different points along ElArish coast to prevent the corrosion of the sandy shore especially for ElArish port and ElArish power plant. So, these rocks gave a real chance for growth of seaweeds vegetation. Seaweeds generally exist in a temperature range between 10 and 25°C (Lobban *et al.,* 1985b). Increasing of the temperature above the ambient was accompanied with extensive reduction in macrophytes (Wood and Zieman, 1969). The thermal pollution by warm effluents became feature with the increase of warm water effluents from the power station where cooling water is readily available and more than that of the receiving waters. Iwanski and Chu (1985) mentioned that the EPRI (Electric Power Research Institute) annotated the effect of cooling-system on surface water and responses of selected aquatic biota (differences in population structures of plankton and microinvertebrates) to thermal discharges from a Tennessee Valley Authority (TVA) power plant. Zieman and wood (1975) showed that the natural communities which were severely damaged by the elevated heat, were replaced by tolerant species of blue-green algal mats (Cairns, 1956; Patrick, 1969; DeSylva and Hine, 1972; Jones and Randall, 1973 & Kolehmainen *et al.,* 1973). They also found that, in the vicinity of Turkey Point Power station, an increase in the thickness of the diatom mat outward from the canal mouth in summer, and a reverse in winter where the innermost sticks had the highest epiphytism. Friedlander *et al.,* (1996) reported that warm seawater effluents (5-10°C higher than ambient) from the Hedera power plant decreased growth rate of red alga

Gracilaria conferta. So, the aim of the present work was preliminary studies on impact of thermal pollution on algal vegetation in front of ElArish power plant.

Materials and Methods

The algal flora were collected from 8 stations lengthwise ElArish coast (~30 Km) during spring 2000 (Map, 1). The selected stations are: ElRisa (I), ElArish port (II), ElMasaaid (III), ElZaranik (IV). ElArish power plant site was subdivided into 4 stations according to the inlet and the outlet of seawater. These stations are the inlet (V), outside the inlet (VI), the outlet (VII), and beside the outlet (VIII). Algal specimens were identified using many references as: Lindau and Melchio, 1926; Fritsch, 1935a,b; Papenfuss, 1968; Cribb, 1983; Womersley, 1984,1987; Cramer, 1987 and Aleem, 1993. Hydrographic conditions were measured using the thermometer for air and water temperature readings, hand refractometer (ATAGO S/Mill Chem. Lab. Scientific Products Ltd) for salinity, a digital pH meter (Teleko AQUAMETR N 5011) for pH and a turbidimeter (Orbeco-Hellige Digital Direct-Reading TURBIDIME- TER) for turbidity.



Map (1): The north of Sinai Peninsula and the studied stations. (I ElRisa, II ElArish port, III ElMasaaid, IV ElZaranik, V-VIII ElArish Power Plant).

Result

Preliminary survey to the distribution of the algal flora was recorded at the studied stations (Table, 1). Ninety-one species were collected of ElArish coast. Fig. (1) showed contribution percentage of the different algal divisions at the studied stations: 50.55 % (Bacillariophyta), 17.58% (Chlorophyta), 16.48% (Rhodophyta), 10.99% (Cyanophyta) and 4.40 % (Phaeophyta).

Most of the green algae were concentrated toward ElArish westward (stations VI and VIII) while the red algae more appeared at ElArish eastward (station I). Meanwhile only 4 species of brown algae were recorded. Some macrophytes were represented by more than one species: *Enteromorpha* (7 species), *Cladophora* (6 species) and *Ceramium* (3 species). Nevertheless, sandy shore and the high salinity (190‰) supported poor algal vegetation at the stations III and IV respectively.

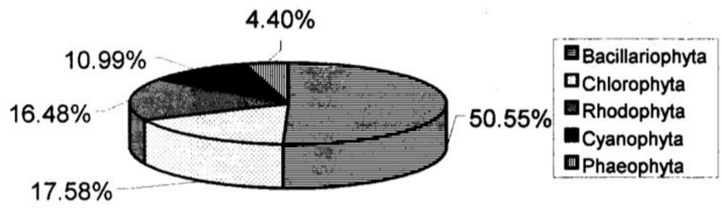


Fig. (1): Contribution percentage of the different algal divisions at the studied stations.

Table (1): The algal species at the studied stations:

Stations / Species	I	II	V	VI	VII	VIII
Chlorophyta:						
Chaetomorpha *linum (Müll.) Kützing*			+			
Cladophora albida (Huds.) Kützing	+			+		
C. crystallina (Kütz.) Hamel	+			+		
C. montagneana Kützing				+		
Cladophora patentiramea Montagne				+		+
C. prolifera (Roth) Kützing	+			+		
C. rupestris (Linn.)Kützing		+		+		
Enteromorpha clathrata (Roth)Grevile				+		+
E. compressa (Linn.) Nees			+	+		+
E. flexuosa (Wulf) Agardh	+			+		+
E. intestinalis (Linn.) Nees	+					+
E. prolifera Agardh		+	+			+
E. ralfsii Bliding	+		+	+		+
E. ramulsa (J.E. Smith) Hooker		+				
Ulva spathulata Papenfuss						+
Urospora penicilliformis Areschoug			+			
Phaeophyta:						
Chorda filum (Linn.) Lamouroux	+			+		
Giffordia indica (Sond.) Papenfuss et Chihara		+				
Pilayella litoralis (Linn.) Kjellman						+
Scytosiphon lomentaria (Lyng.) Agardh	+			+		
Rhodophyta:						
Acanthophora najadiformis (Deli.) Papenfuss	+					
Bangia fuscopurpurea (Dill.) Lyngbye in Hamel	+	+				
Ceramium gracillimum (Harv.) Mazoyer		+				
C. rubrum (Huds.) Agardh	+					

Table (1): cont.:

Species / *Stations*	I	II	V	VI	VII	VIII
C. tenuissimum (Lyng.) Agardh				+		
Digenia simplex (Wulf.) Agradh	+					
Erythrotrichia carnea (Dill.) Agardh	+					
Gelidium crinale (Turn.) Lamour	+			+		
Gigatrina sp.		+				
Gracilaria edulis (A.Ag.) Silva	+					
Halosaccion ramentaceum Kützing			+			+
Hypnea hamulosa (Turn.) Montagne		+		+		
Polysiphonia variegata (Agar.) Zanardini	+		+	+		+
Pterocladia nana Kamura		+				
Spyridia filamentosa (wulf.) Harvey	+					
Cyanophyta:						
Gloeocapsa mgma (Bréb.) Kützing		+				
Hapalosiphon fontinalis (Agar.) Born			+			
Lyngbya aesturaii Liebmann in fremy			+		+	+
L. majuscula Harvey in fremy					+	
Merismopedia sp.			+			
Nostoc carneum Agardh			+			
Oscillatoria amphibia Agardh					+	
O. princeps Vauch					+	
O. sancta Kützing		+			+	
Spirulina major Kützing				+		
Bacillariophyta:						
Achnanthes sp. Hustedt					+	
Amphora holsatica Hustedt					+	
A. ovalis Kützing					+	
A. schroederi Hustedt					+	
A. subrobusta Hustedt					+	
Bacillaria paradoxa Gmelin					+	
Cocconeis pediculus Ehrenberg		+	+		+	
Coscinodiscus excentricus Ehrenberg					+	
C. lineatus Ehrnberg					+	
Cyclotella distinguenda Hustedt			+			
C. sp.	+					
Cymbella affinis Kützing					+	
Diatoma vulgare Bory			+	+		
Fragilaria construens Grunow	+		+		+	
F. leptostauron Hustedt		+				
F. robusta Hustedt					+	
F. spinulifera Hustedt	+					
F. sp.	+					
Grammatophora marina (Lyng.) Kützing			+			
Licmophora flabellata (Grev.) Agardh	+	+	+	+		
L. onassis Hustedt			+			
Mastogloia sublatericia Hustedt					+	

Table (1): continued:

Species \ Stations	I	II	V	VI	VII	VIII
Melosira granulata (Ehre.) Ralfs						+
M. pulchella Hustedt			+			
Meridion circulare Greville			+			
Navicula bacillum Ehenberg		+	+		+	+
N. cuspidata Kützing					+	
N. humerosa Brèbisson in Wm. Smith					+	
N. sp.1				+	+	
N. sp.2					+	
N. subdivisa Grunow					+	
N. typografica Hustedt			+			
Nitzschia angustata (Wm. Smith) Grunow			+			
N. denticula Grunow					+	
N. holsatica Hustedt					+	
N. longissima Brèbisson Ralfs in Pritchard			+			
N. palea (Kütz.) Wm. Smith					+	
N. vacua Hustedt				+	+	+
Pleurosigma delicatulum Wm.Smith.					+	
Rhopalodia gibba (Ehre.) O. Müll					+	
Surirella Karstenii Hustedt					+	
S. splendida Hustedt			+	+	+	+
Synedra ulna Kützing					+	
Tabellaria flocculosa (Roth) Kützing				+		+
Triceratium favus Ehrenberg					+	
T. sp.					+	

Concerning hydrographic conditions at the studied areas, air temperature ranged between 29 and 33°C (Fig. 2,b). Salinity values of ElArish coast (Fig. 2,c) ranged between 40 and 44‰, except at station IV, a very height (190‰) was recorded. The pH values (Fig. 2,d) were slightly alkaline, it ranges between 7.80 and 8.70. As regards turbidity (Fig. 2,e), minimum level (1.2 N.T.U.) was recorded at ElArish port while the maximum level was 12.6 N.T.U. at ElMasaaid station. Maximum water temperature 35 °C was registered at the outlet of ElArish power plant (Fig. 2,a). The cooling water discharge was about 15°C above the ambient temperature of the receiving water. This led to the thermal point for many organisms and complete disappearance of seaweeds. The reduction in seaweeds is accompanied by excessive growth of Bacillariophyta and Cyanophyta (Table, 1). The diatom flora at station VII extended its growth to give higher crops than blue-green algae. The blue greens are represented by 5 species of Oscillatoriaceae: *Oscillatoria sancta, O.princeps, O.amphibia, Lyngbya majuscula* and *L. aestuarii*.

Among forty-six species of diatoms which were recorded at the studied area (Table, 1), twenty-four species of tolerant diatoms were found only at the cooling water (station VII). Besides, 6 species were recorded to be associated with other stations. These six species were: *Fragilaria construens, Surirella splendida, Nitzschia vacua, Cocconeis pediculus, Navicula* sp.1 and *N. bacillum.* More than one species were identified of the

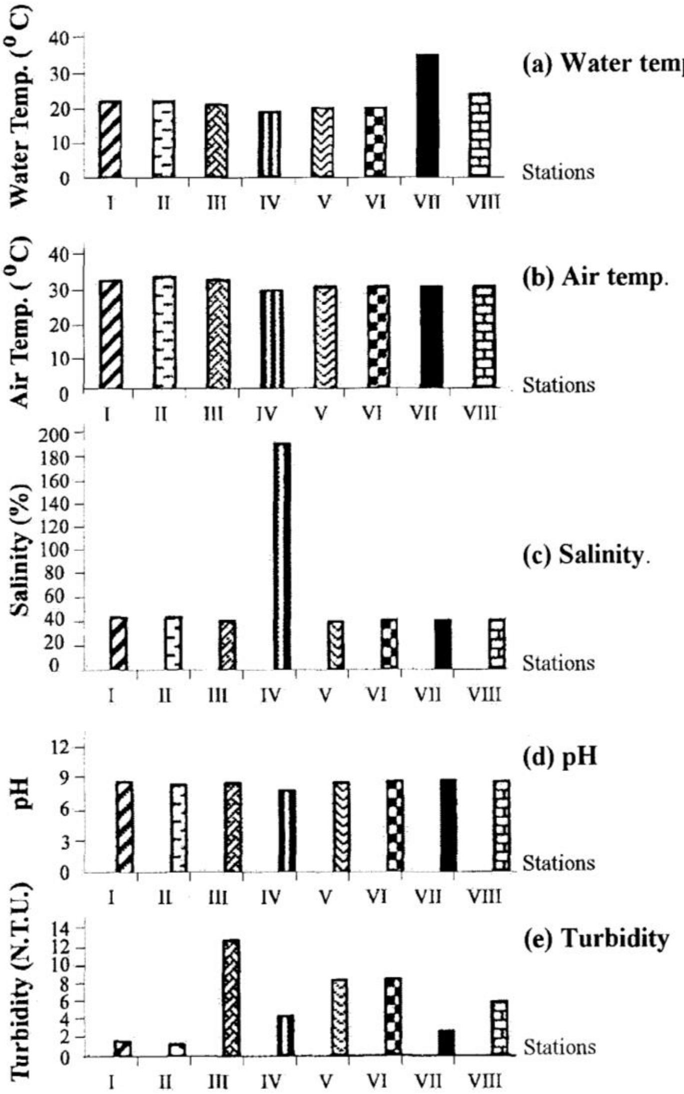


Fig. (2): The variations of water temperature (a), air temperature (b), salinity (c), pH (d) and turbidity (e) at the studied stations.

genera; *Amphora (A. ovalis, A. subrobusta, A. holsatica, A. schroederi)*; *Fragilaria (F. construens, F. robusta)*; *Nitzschia (N. palea, N. paradoxa, N. holsatica, N. denticula)*; *Triceratium (T. favus, T.* sp.); *Coscinodiscus (C. excentricus, C. lineatus)*; *Navicula (N. bacillum, N. subdivisia, N. humerosa, N.* sp. 2, *N. cuspidata)* and *Surirella (S. karstenii, S.*

splendida). Colonies of a different nature were seen in *Navicula* sp. 2. Here large numbers of individuals occur enclosed in a common tubular mucilage-envelope, which was sometimes, richly branched. Also, the cooling water station was characterized by the appearance of: *Cymbella affinis, Mastogloia sublatericia, Synedra ulna, Pleurosigma delicatulum, Rhopalodia gibba* and *Achnanthes* sp.. Generally, the main component in ElArish Power Plant (outlet) was blue-green algae (*Oscillatoria sancta, O. princeps, O. amphibia, Lyngbya majuscula* and *L. aestuarii)*; while the most abundant diatoms were: *Amphora ovalis, Nitzschia vacua, Cocconies pedicals, Bacillaria paradoxa, Achnanthes* sp., *Rhopalodia gibba Navicula bacillum, N.* sp.1, *N.* sp.2 and *N. cuspidata.* Station VIII (beside the outlet), at the ambient temperature, was registered decreasing in blue greens (one species) and diatoms (4 species). At the same time, it was accompanied by appearance of seaweeds, green algae (8 species), brown algae (one species) and red algae (2 species). The receiving water (inlet) at station V was characterized by abundance the following species: *Nitzschia angustata, N. longissima, Cyclotella distinguenda, Navicula typografica, Meridion circulare, Melosira pulchella, Grammatophora marina, Licmophora onassis* and *L. flabellata.*

Discussion

The development of seaweeds communities at ElArish coast took place recently where the algal spores were able to settle at the hard shore. This was the first record of the seaweeds vegetation at ElArish coast. It succeeded after the erection of rocky pavements at the different points along the coast to protect the shore from the highly corrosion resulting from the sea and the power plant operations, particularly after construction ElArish port. With respect to the effect of the cooling water, Bacillariophyta formed 50.55% of the recorded individuals, followed by Chlorophyta, Rhodophyta, Cyanophyta and finally by Phaeophyta.

Temperature and salinity were the most fundamental hydrographic factors affecting the species composition of the algal vegetation clusters. The salinity of the Mediterranean varied from 38.4 to 39.0‰ (Lobban *et al.*, 1985a) because there is evaporation and little fresh water influx. At ElArish coast salinity ranged between 40 and 44‰ where the algal vegetation can exist. As shown in the present study, extreme value (190‰) at station IV that was neighbor ElArish salt works was accompanied with disappearance of the algal vegetation.

The thermal effect of cooling water discharge was one of the by-products of ElArish power plant. It raised the temperature with 10-15°C above the ambient value at station VII. This thermal pollution disturbed the population structures and standing crops of phytoplankton and seaweeds communities. Seaweeds were completely disappeared and this may attribute to the lethal effect of high temperature, which affected the molecular activities and properties, and virtually on all aspects of metabolism. Kuppers and Weidner (1980) studied the effect of temperature on enzyme activities of six *Laminaria hyperborea* enzymes from diverse metabolic pathways. As the temperature increases further, more and more enzymes become denaturated.

Lipkin (1972) registered 6 species of diatoms and 6 species of blue greens in the Mediterranean Sea. But now the study recorded 46 species of diatoms and 10 species of blue- green algae from the studied stations. Excessive growth of diatoms (30 species) in addition to 5 species of Cyanophyta was recorded only at the outlet (VII). These species may be more tolerant and adapted physiologically or competitively at the warmer than normal temperatures, therefore species composition may be changed. Six species of the collected diatoms was adapted with the warmer water and at the same time was existing at the normal water temperature. However, the most abundant diatoms and blue-greens, certainly belong to the flora of the cooling water of the power plant, are not characteristic thermal organisms but are most probably "thermo-tolerant" organisms from the surrounding areas. Large number of *Navicula* individuals may occur enclosed in tubular mucilage-envelope as a colony and may be for more protection. This condition is particularly frequent in marine forms. Within the envelopes, the individuals are freely motile, but they can also occur as solitary cells (Fritsch, 1935a).

Many northern European countries now recommend that when a new power plant is built and is cooled by seawater, the temperature increase that results after mixing should not exceed 2°C and in the summer, the temperature of the mixed water is not to rise above 26°C (Lobban *et al.*, 1985b). In spite of this recommendation, the species composition of an area may be changed in the absence of thermal damage to individuals.

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دراسات مبدئية لتأثير التلوث الحرارى على الكساء الطحلبى قبالة محطة كهرباء العريش

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لقد سجل المسح المبدئى للكساء الطحلبى ولأول مرة على ساحل العريش (حوالى ٣٠ كم) فى موسم الربيع لعام ٢٠٠٠ . وقد تم تعريف ٩٠ نوع من الطحالب البحرية من ٨ محطات ممتدة ما بين الريسة فى شرق العريش حتى الزرانيق فى غرب العريش . وقد سجلت الدراسات ١٦ نوع من الطحالب الخضراء و ٤ أنواع من الطحالب البنية و ١٥ نوع من الطحالب الحمراء و ١٠ أنواع من الطحالب الخضراء المزرقة وأخيرا ٤٦ نوع من الدياتومات . وقد وجد أن محطة كهرباء العريش تؤثر سلبا على طبيعة المنطقة المحيطة بها. فهى تسبب تآكل واضح للشاطئ الرملى علاوة على الصرف الحرارى من محطة خروج مياه التبريد على البحر مباشرة. هذا أدى الى اختفاء تام للطحالب البحرية (seaweeds) بينما قابل ذلك نمو كبير لأنواع أكثر احتمالا للصرف الحرارى. فقد سجل ٢٩ نوع منها (٢٤ نوع من الدياتومات و٥ أنواع من الطحالب الخضراء المزرقة) .