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FULL LENGTH ARTICLE

Coastal engineering and Harmful Algal Blooms along Alexandria coast, Egypt

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KEYWORDS

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Abstract The coast of Alexandria has been subjected to successive engineering alterations since 1998. Such alterations have affected the topography of the coast as well as the water quality, the phytoplankton productivity and diversity. In 1998 protective wave breakers were built in order to reduce erosion and create new beaches. This resulted in the formation of relatively large semi-closed, shallow lagoons. Due to their shallow depth and the partial stagnation of their waters, these lagoons became a suitable environment for algal blooms. Corrective measures were then taken around 2010 to reduce the harmful effects caused by the previous coastal modifications.

The phytoplankton composition and its standing crop became totally different during the two periods. The most important bloom was caused by *Micromonas pusilla* forming a heavy green tide accompanied by a bloom of *Peridinium quinquecorne*. Although there were no fish or invertebrate mortality, this bloom caused economic losses to internal tourism. In the absence of any Environmental Assessment, the coastal engineering works increased the harmful algal blooms in Alexandria coastal waters, even after corrective steps were taken to mitigate the harmful effects.

Introduction

Coastal areas are remarkably dynamic environments rich in natural resources, biological diversity and with high potential for all kind of commercial activities. The rising pressure over the coastal zone at the global level has been broadly dealt with the scientific literature (UNEP, 1991). The junction of multiple interests, such as fisheries, tourism, ports and industrial activities makes these areas the most populated in the world, demanding efforts of protection of the productivity and quality of the coastal resources and human health of coastal communities (Tagliani et al., 2003).

Alexandria coasts are certainly areas where both human activities and environmental pressures are at maximum. Erosion and deposition of solid materials by the action of water movement are continuous processes along the shoreline. As a result, beaches had to be protected since 1934 in order to prevent further erosion and to provide new recreational beaches (El-Wakeel et al., 1980). A series of groins and detached breakwaters were built during the last two decades to mitigate hot spot beach erosion. At a later stage the coastal area of Alexandria was subjected to further coastal engineering works which affected not only the topography of the area but also the water quality, productivity and phytoplankton communities of the coastal area. As a later stage, it soon appeared that correc-

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tive measures have to be taken to mitigate the negative impacts of the coastal works which had been carried out. Three phases therefore have to be distinguished (Report of Engineering Center-Faculty of Engineering, Alexandria University, personal communication).

Phase (1): 1998–2003 (Fig. 1a)

A series of groins and detached breakwaters were built perpendicular to the coastline.

But these structures soon proved to be ineffective in preventing beach erosion.

Phase (2): 2003–2007 (Fig. 1b)

T-shaped breakwaters were built extending for 400 m parallel to the coast in front of El-Mandara (Stations 1 & 2)120 m offshore, all structures being 3 meters in elevation above the sea level. Several artificial beach nourishment projects were also carried out with the addition of no less than 250cu.m sand per meter length. In addition, groins perpendicular to the beach and protective wave breakers were also built. As a result, relatively large semi-closed shallow lagoons about 3 m depth for swimming and recreation were created (Ismael and Halim, 2008).

Phase (3): Corrective works after 2007 (Fig. 1c)

After completing the second phase of coastal engineering, it appeared that wave action causes strong erosion in front of El-Mandara (Stations 1 & 2) and that erosion extended to the Corniche (the sea front) wall in the unprotected segments. Following the recommendations of the Organization for planning of the Alexandria region, all breakwaters were submerged below the sea level. This change led to minimizing the impact on marine life, erosion and sedimentation.

At any given time and place, the degree of diversity and amount of biomass in a natural assemblage of phytoplankton represent a balance among numerous environmental factors including irradiance, temperature, salinity, grazing and nutrient input. When these factors undergo rapid change, the new conditions may be favorable to some species and unfavorable to others. Shifts within the plankton assemblage may be gradual, occurring over the course of several weeks or can sometimes occur within just a few days (Sommer et al., 1993).

The aim of the present study is to investigate the impact of successive coastal engineering processes on the phytoplankton community from Miami to El-Mandara during the two phases of modifications (2007 & 2011) to complete the work of Ismael and Halim (2008).

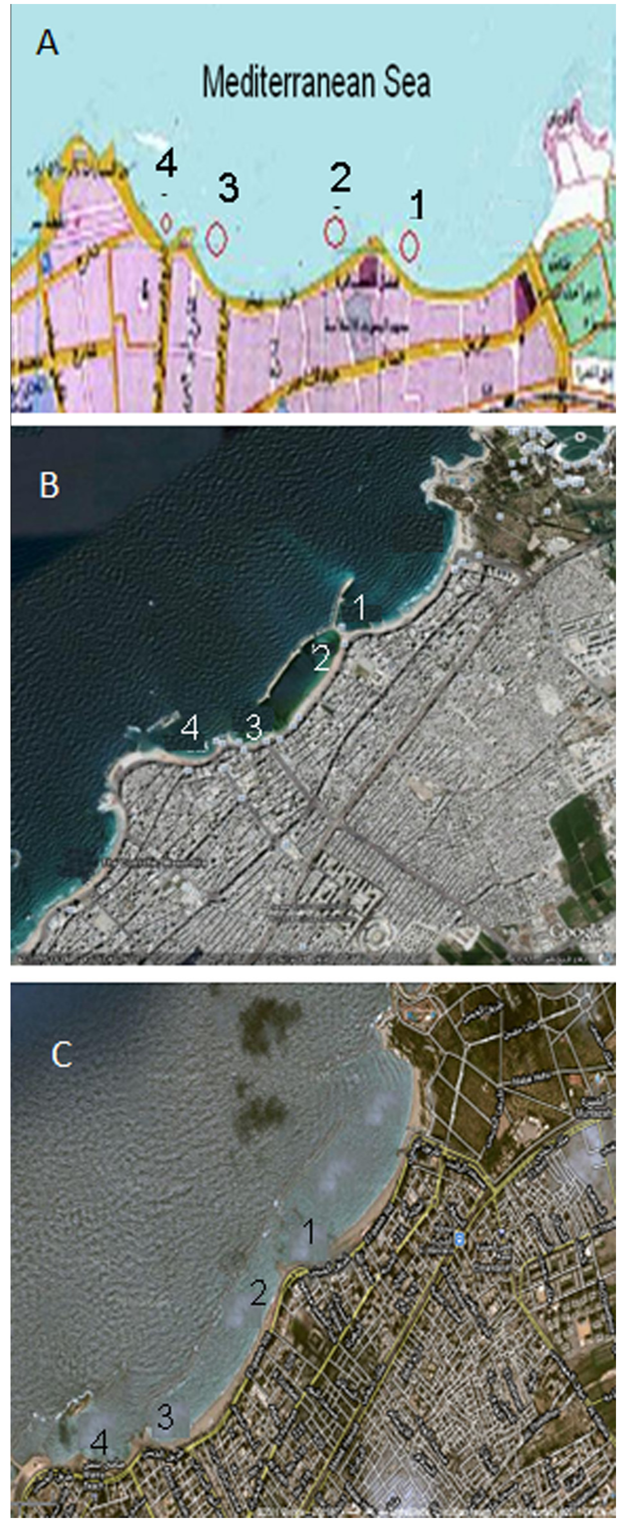

Figure 1 Coastal engineering and station position during the three phases. (A) phase 1 (1998–2003), (B) phase 2 (2003–2007), (C): phase 3 (after 2007).

Material and methods

Sample collection

All samples were collected during the period from 26 June to 15 September 2007 and from 16 June to 17 August 2011 from Miami Beach (St. 4), El Asafra (St. 3) to El-Mandarah (St. 1 and 2) along about 3.75 km of the coast (Fig. 1).

Environmental parameters

Salinity, temperature and pH were measured *in situ* using HANA instruments; salintest model HI 98203 and pH-°C model HI 98127. In addition, one liter of water sample from