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Short Communication

Use of Hyperspectral Remote Sensing to Cyanobacteria in the Coastal Waters of the Persian Gulf

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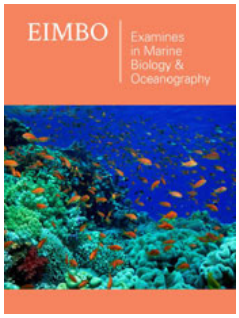

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Abstract

The severe threat to coastal waters by Cyanobacterial blooms is increasing, particularly in the regions with fish and shrimp farming activities. It is comparatively easy to detect the blooms optically, due to the surface abundance of cells, the existence of Phycocyanin pigments, and the raised backscatter associated with cell size and gas vacuoles. Remote sensing methods play imminent role in detecting the abundance cyanobacteria cells. Multispectral and hyperspectral sensors have showed adequate performance and become pertinent means of detecting these cells in the Bushehr (Iran) coastal waters within a 5-day period. Sentinel-2 satellite images over the Bushehr region showed that developed algorithms could meaningfully estimate the abundance of cyanobacteria cells in the coastal waters of Bushehr area, where there are high activities of fish and shrimp farming in the region. Indeed, springtime detections showed that the abundance of cyanobacterial cells varied between1.62×10-4 and 3.91×10-3 per liter. The maximum abundance occurred within the band near the coastline and lower abundances offshore. Using these data, we demonstrated that a spectral-shape algorithm requiring minimal atmospheric correction could be used to detect cyanobacterial blooms. Likewise, with the availability of high spectral resolution data and appropriate atmospheric correction, it is possible to develop a potential early warning system based on the abundance of Microcystis at the coastal surface waters of the Persian Gulf.

Keywords: Hyperspectral; Cyanobacteria; Phycocyanin pigments; Microcystis; Photosynthetic; Microorganisms; Algal bloom

Abbreviation: MODIS: Moderate Resolution Imaging Spectrometer; MERIS: Medium Resolution Imaging Spectrometer

Introduction

Cyanobacteria are a genetically diverse group of photosynthetic microorganisms (formerly known as blue-green algae) that occupy a broad range of habitats on land and water all over the world. Under certain environmental conditions (including excessive nutrients), cyanobacteria rapidly multiply to create a bloom that is sometimes referred to as a cyanobacterial harmful algal bloom (cyanoHAB) [1,2]. Some cyanobacteria produce toxins that can kill wildlife and domestic animals and cause illness or death in humans through exposure to contaminated freshwater [3] or by the consumption of contaminated drinking water, fish, or shellfish [2]. The occurrence of toxic cyanobacteria in aquaculture systems is a matter of concern due to its capability to produce toxin known as microcystin [4]. This study was performed to determine the presence, abundance and toxic potential of cyanobacteria in selected aquaculture systems in Bushehr, Iran, and to identify the potential risks in aquaculture water.

Methodology

The Persian Gulf covers large (length of 800km) coastal environments (Figure 1) and plays a key role in the life and economy of their neighborhood countries. The Chlorophyll-a concentration is relatively high within the related coastal waters due to the influence of nutrients by coastal cities, tides and low slope of shallow tidal regions (bottom depth <10m), resuspension, wintertime freshwater plums, and fronts [5]. Chlorophyll-a concentration measured by spectrophotometer UV/visible (Analytik Jena, Specord 210) according to ROPME [6] guidelines. In this study, we utilized a predeveloped algorithm based on MERIS (Medium Resolution Imaging Spectrometer) [7]:

$$ss(\lambda) = nLw(\lambda) - nLw(\lambda^-) - \{nLw(\lambda^+) - nLw(\lambda^-)\}\frac{[(\lambda - \lambda^-)]}{(\lambda^+ - \lambda^-)} \quad (1)$$

Figure 1: Delvar coastal area, Bushehr, Persian Gulf, Iran. The red rectangle represents a shrimp farm site.

where SS(λ) represents the spectral slope, where SS is the spectral shape, nLw is the normalized water leaving radiance, λ is 681nm, λ^+ is 709nm and λ^- is 665nm. Satellite data obtained from Sentinel-2 and Moderate Resolution Imaging Spectrometer (MODIS) on board NASA's Aqua and Terra Satellite. Sentinel-2 is an earth observation mission from the copernicus program that systematically acquires imagery at high spatial resolution (10m to 60m) over land and coastal waters. MODIS Aqua and MODIS Terra provide remotely sensed data in three different spatial resolutions; 250m (bands 1-2), 500m (bands 3-7), and 1km (bands 8-36).

Preliminary Result and Discussion

Analyses showed that water temperature followed a positive trend during the 2002-2020 period in the Persian Gulf (Figure 2). Likewise, satellite images showed irregular variation in the abundance of cyanobacteria cells within the study area (Figure 3). Indeed, the abundance of cyanobacteria cells increases towards the shore. This leads to the fact that temperature increase has influences the abundance of cyanobacteria. Likewise, fish farmers and policy makers can utilize the results of this study as an early warning system, in order to reduce future risks and damages to the local economic activities.

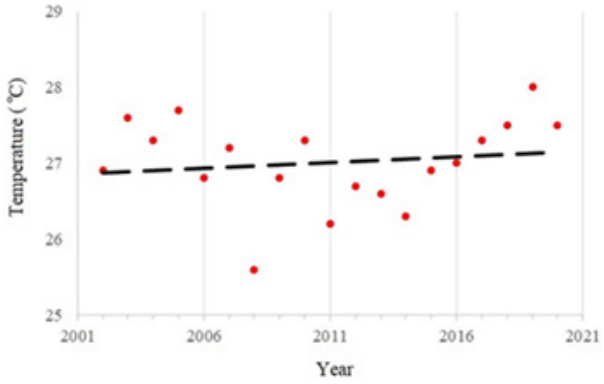

Figure 2: Water surface temperature trend of the Persian Gulf during the 2002-2020 period.

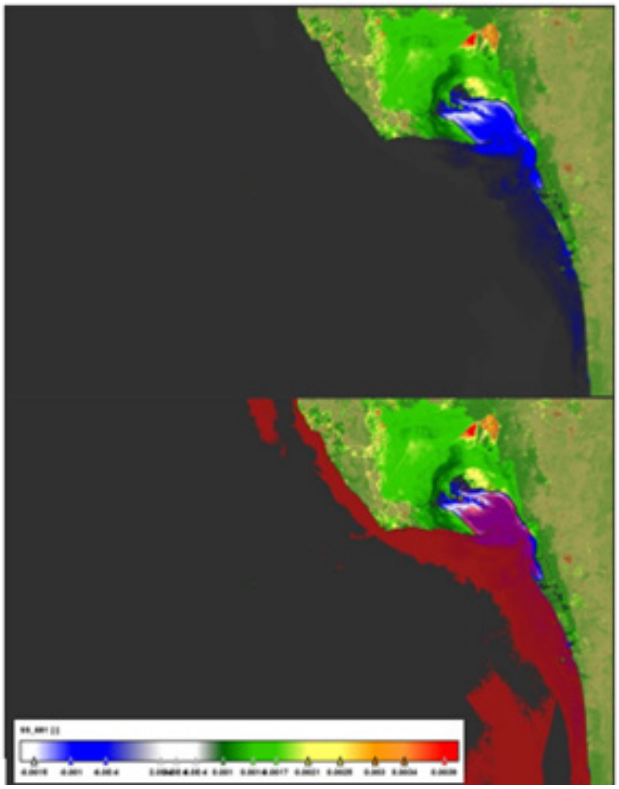

Figure 3: Sentinel-2 satellite image on 19 May 2021 before (upper) and after (lower) applying the spectral slope algorithm at 681nm.

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