Using Remote Sensing Data for Assessing the Optical Characteristics of Alexandria Coastal Water, Egypt.

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Abstract

The development of sea surface color data observations has opened new perspectives or the understanding of marine environmental processes, due to their great potential for providing novel information on biological, geochemical and physical processes of the sea. This paper aims to use Landsat TM imagery as a very efficient way for sea surface color data. Such data can be used for to derive optical properties of coastal water of Alexandria Coast, that is subjected to human stress from land base activities.

Therefore two landsat images of the coastal zone were collected in August, 1990 and May, 2000). The images were processed to enhance the water color and to derive surface temperature information of the coastal water. This is accomplished by stretching of the bands (1,2 and 3) that are laying in the visible range of the spectrum (bands 1, 2 and 3). These bands are composed and assigned to Blue, Green and Red colors respectively, for emphasizing and identifying the optical characteristics of nearshore water. Six sample profiles have been drawn for different regions along Alexandria coast from Abou Kir Bay in the east to western harbor in the west while sample no 1 represents the clear water (case 1 water) collected in the offshore water. On the other hand, to analyze of the impact of different land-use activities, the images are enhanced for land-use/land-cover discrimination by stretching bands 2, 4 and 7 and assigned to Blue, Green and Red colors respectively.

Results showed that the anthropogenic input to the marine environment is reflected to different image profile analyses. The composite images show marked differences in the distribution water constituents between the oligotrophic character of open sea waters (case 1 water) and the near shore water (case 2 waters). The color-sliced thermal band illustrate the thermal distribution for the Alexandria coastal area water.

Keywords:
Coastal Water Quality, Remote Sensing, Environmental monitoring

1. Introduction

Monitoring, protecting and improving the quality of waters is critical for targeting conservation efforts and improving the quality of environment. Methods currently used to monitor water quality across the landscape consists of in situ measurements or collection of water samples for analysis in the laboratory. These techniques, while accurate for a point in time and space, are time consuming and expensive and do not give the synoptic views of the landscape necessary to allow management decisions that can effectively control or improve water quality.

The Alexandria coastal zone is about 42 km long, extending from El-Dekhaila in the west to Abu Quir in the east, and consists of pockets and embayment beaches morphology. In addition to its moderate temperature in summer and winter, its beaches, with soft sands and magnificent scenery, are considered very important natural resources. The coastal zone of Alexandria is presently experiencing a number of problems resulting from a considerable amount of wastewater is discharged into the coastal zone of Alexandria from the surrounding area as described by (Saad, 1985, Said, 1995 and Hassan, 1996). This occurs extensively at six regions, Edku lake inlet, El Tabia pumping station , Eastern Harbor, western harbor and Mamoura region.

The purpose of the study is to evaluate the potential of using remotely sensed digital data from Landsat satellite (TM sensor), to extract information that help in the monitoring system for Alexandria coastal water quality. The color and surface temperature information of the coastal water can be derived from satellite-based observations, as well reflects the main environmental processes occurring along the coastal water. These processes can detected through measuring the parameters that cause changes in the optical characteristics of surface waters. Each of the components of coastal water contributes to the values of optical properties for the sea.

The optical properties of sea water are divided into inherent and apparent properties. The inherent properties are those associated with the absorption and scattering of light. The apparent optical properties are those characteristics of the water body that are dependent on the ambient light, therefore, the measurements cannot be taken in the laboratory, only *in situ* . Apparent optical properties are Secchi disk depth and Irradiance attenuation. Stramski and Kiefer (1991) and Morel (1991a) give excellent reviews of the optical properties of marine particles. Observing the marine environment from satellites is a more recently established method of data capture than aerial photography, and has undergone a prolific increase in usage over the last decade. The satellite data are collected in inherently digital form, and are therefore immediately amenable to computer processing.

The remote sensing has been started in Egypt since three decades. The techniques of image processesing were commonly used for the qualitative studies for the marine and coastal environment i.e. image classification, change detection techniques, etc.., among these studies are Klemas and Abdel Kader (1982); Inman and Jenkins (1984); Frihy (1988); Elwany et al. (1988); Fanos and Khafagy (1989); Ahmed, (1991); Frihy et al., (1992); Warne and Stanley (1993); El-Raey et al. (1995; 1997, 1998); Yehia, (1998), Ahmed et al., (2000 a,b; 2001; 2002 and 2003).

2. Methodology

In this study, TM landsat images have been used for the years 1990 and 2000 as shown in figure (1). Landsat sensor measures radiation in seven bands of the electromagnetic spectrum with spectral resolution of 30m except for band 6 which measures emitted thermal infra-red radiation and has a resolution of 120 m. The processing of these color images (two dates) has been carried out mainly to enhance the water color and to map the thermal distribution. ERDAS Imagine 8.6 software package is used to process and analyze the acquired images.

First, The coastal zone of Alexandria is extensively selected for six regions, based on the existing natural and human interventions to the coastal water, the six profiles have been drawn for the six regions representing the clear water (case 1 water) or offshore water for profile 1 and case 2 waters or near shore water for the other five profiles Mamoura region (profile no 2), El Tabia pumping station (profile no 3), Edku lake inlet (profile no 4), Eastern Harbor (profile no 5), western harbor (profile no 6). These profiles are selected based on the reflectance measurements derived from processing the images. The location of selected sites is shown in figure (2).

Secondly, as surface water temperature is the basic parameter for the deviation of the thermal behavior of the environment, a thermal classification of both images has been conducted using the thermal infrared (10.4 to 12.5 um) band 6 that measures the amount of infrared radiant flux emitted from surfaces. The apparent temperature is a function of the emissivities and true or kinetic temperature of the surface. It is useful for locating geothermal activity, thermal inertia mapping for geologic investigations, vegetation classification, vegetation stress analysis, and soil moisture studies. The resulted temperature represents an “effective at-satellite temperature of the viewed Earth-atmosphere system under the assumption of unity emissivity”. The consideration of emissivity of the surface cover types would include the additional problem of mixed pixels in a 60 x 60 m 2 area. Otherwise the mixed signatures help to accept the assumption of unity emissivity for this kind of application.

The thermal bands of the satellite images were transformed into surface temperature values. The digital numbers were transformed into absolute radiance in the two landsat sensors (TM5 and TM7), using the following equation :

$$L = (Lmax - Lmin)/255 * DN + Lmin \qquad (1),$$

where L is the spectral radiance, Lmin and Lmax [mW cm-2 sr-1 µm-1] are spectral radiances for each band at digital pixel numbers 0 and 255 respectively.
Using this equation with the TM landsat 5 Lmin and Lmax the values 0.124 and 1.560 [mW cm-2 sr-1 µm-1] respectively.
On the other hand, the using of this equation with the TM landsat 7 the following reference values are given: ETM + Spectral Radiance Range:
Low Gain: Lmin - 0.0 Lmax - 17.04 [mW cm-2 sr-1 µm-1]
High Gain: Lmin - 3.2 Lmax - 12.65 [mW cm-2 sr-1 µm-1]

The spectral radiances L lambda were converted into effective satellite temperatures T by

$$T= K2 / \ln (K1 / L +1) \qquad (2)$$

where K1, K2 are calibration constants. By applying this equation on the two types of TM sensors, we calculated the following;
For Landsat TM 5 the constants are K1= 60,776 and K2 = 1260,56 [mW cm-2 sr-1 µm-1]
For Landsat TM 7 the constants are K1= 666,09 and K2 = 1282.71 [mW cm-2 sr-1 µm-1]

3. Results and Discussions

Figure (2) shows the enhanced images in both dates for water color discrimination. The yellowish brown color groups together all the plumes due to freshwater discharges entering the sea. This color indicates the presence of organic compounds with sufficient concentrations in these freshwater plumes. The dark blue color) for clear water (case 1 water), where clear water absorbs relatively little energy having wavelengths less than 0.6 um. High transmittance typifies these wavelengths with a maximum in the blue-green portion of the spectrum. The brown color at the inlet of Abu kir., the reflectance of water changes with the chlorophyll concentration involved. Increases in chlorophyll concentration tend to decrease water reflectance in blue wavelengths and increase it in green wavelengths.

Six profiles were drawn for the two enhanced images in figure (3). It is obvious that the clear water profile sample (1) shows maximum reflectance in band 1 and least reflectance in band 3 and appear in blue color in the image as the blue (0.45 to 0.52 um) band 1 provides increased penetration of water bodies, The shorter-wave length cutoff is just below the peak transmittance of clear water, Wavelengths below 0.45 um are substantially influenced by atmospheric scattering and absorption. Also, this is due to that the red (0.63 to 0.69 um) band 3 chlorophyll absorption band of healthy green vegetation that represents one of the most important bands for vegetation discrimination. Profile of sample (4) shows least reflectance in band 1 and relatively high reflectance in band 2 and 3 as it represents Edku outlet where the discharge of agricultural wastes of EL-Maadiya channel, this is due to the presence of dissolved organic matter (yellow matter) that absorbs very little in the red, but its absorption increases rapidly with decreasing wavelength and can be significant at blue wavelength. Therefore, in coastal water, the yellow matter is the dominant absorber in the blue end of the spectrum. Profiles of samples (2,3,5,6) show relatively low reflectance in band 1 and higher reflectance in both bands 2 and 3 due to urban activities influence on sample no 2, thermal pollution of el-tabia pumping station at sample no 3, organic particles due to sewage discharge at sample no 5 and oil pollution resulting from shipping wastes at sample no 6.

For the temporal analysis, it is obvious that landsat classified image for year 2000 shows enhancement in the coastal water quality than landsat 1990 due to enforcement of environmental law 1994 for preventing the wastewater discharges into sea. Temporal reflectance analyses of the selected coastal water sites from satellite images TM 1990 and 2000. Also, Land use maps have been generated for the coastal area illustrating the landuse activities along the coast.

Band 6 for thermal infra-red was used for thematic mapping of the coastal water as illustrated in figures (6, 7). Simultaneous measurements of temperature of water bodies directly at surface 1991 and 2000 correspond with the calculated temperature in a range of 1 Kelvin by an emissivity of water of about 0.98 –0.99. Temperatures were converted from degree Kelvin into degree Celsius for simpler handling. After calculation of day-night differences and the changes of day-night differences between 1991 and 2000 the values were rounded to 1° Celsius. It is obvious from the figures that the highest temperature detected from thee satellite were at the location of discharge of the pollutants.

Figure (1) Landuse maps for the Alexandria Coast for 1990 and 2000

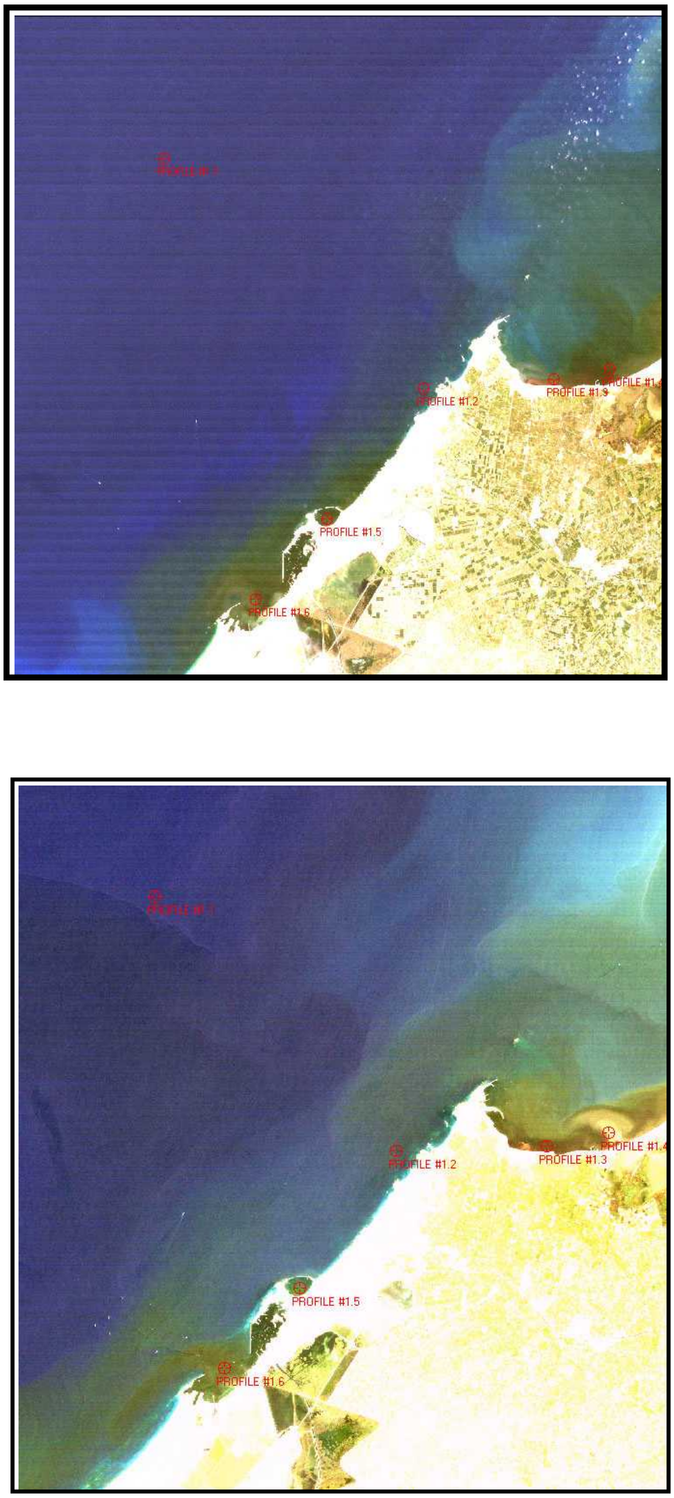

Figure (2): Location map of the selected sites of coastal water along Alexandria coastal zone

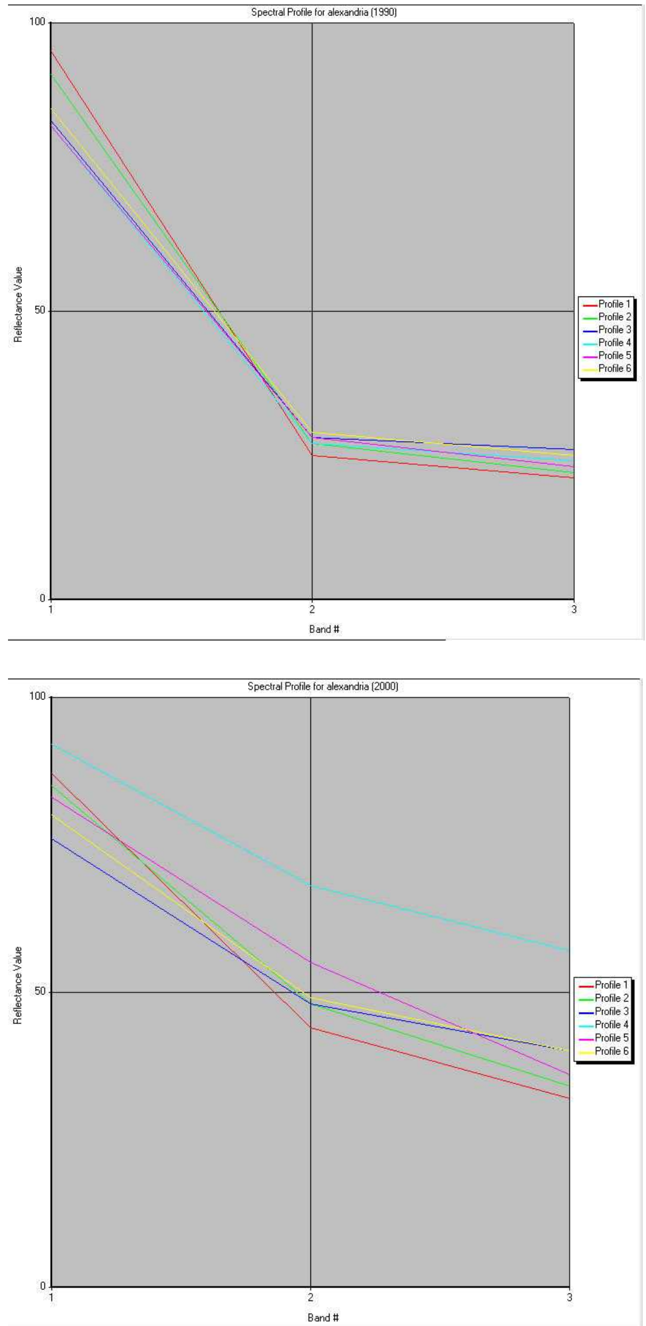

Figure (3): Profiles of two images (1990 and 2000)

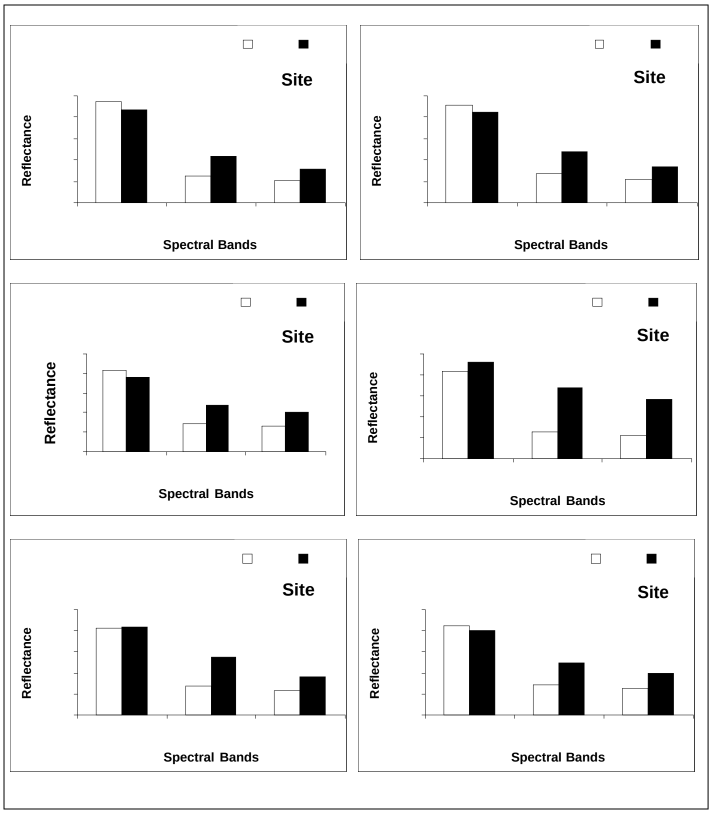

Figure (4): Temporal reflectance analyses of the selected coastal water sites from satellite images TM 1990 and 2000

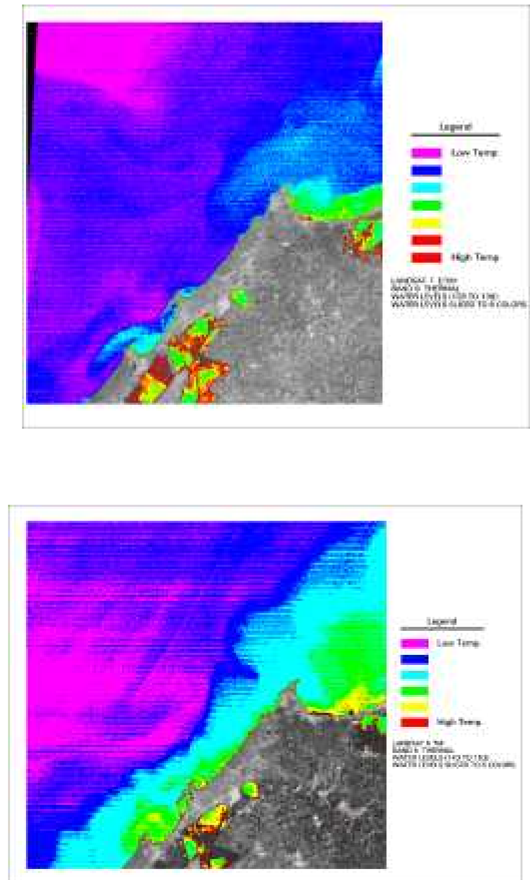

Figure (5) Thermal maps for the Alexandria Coast for 1990 and 2000

4. Conclusion

Remote sensing can play a vital role in reducing the cost, labor, time required to develop statewide water clarity assessments that are currently impossible by traditional field operations. The purpose of the study is to evaluate the potential of using remotely

Several patterns of near-cost features were derived from the composite images. The results obtained show differences in the distribution of water constituents. As the reflectance value tend to be relatively low in clean waters and high with increasing concentrations of particulate materials. Therefore the reflectance profiles were used to identify the presence and concentrations of water constituents and parameters closely related to a variety of environmentally important variables and to assess the impact of coastal and fluvial runoff. In general, the reflectance of water increases with increased suspended sediments concentrations. Chlorophyll concentration is inversely related to suspended sediment concentrations. Reflectance and radiance are inversely related to concentration of chlorophyll.

Therefore, the enhanced images emphasize the existence of particles, dissolved substances within the near shore water, which represent water pollution. These pollutants reflect strongly other color than blue instead of absorbing such colors in case of clear water. Consequently, the color level with respect to blue was interpreted as indicator of the pollutant concentration in water.

Also, Seawater thermal mapping of the study area was generated by using the thermal band of the two landsat images. No atmospheric correction was carried out for this comparative study. In this way the term surface temperature is not correct but should describe the representation of the thermal behaviour of surface cover types under these discussed conditions. The temperatures are also not directly comparable with air temperatures normally measured 2 meters above ground.

5.References

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