# Environmental hazards in the El-Temsah Lake, Suez Canal district, Egypt

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## 1. Abstract

Chemical and biological analyses were integrated using remote sensing GIS techniques to evaluate the environmental pollution of El-Temsah Lake, in the Suez Canal, in order to provide critical data to enhance development planning and economic projects within the study area. Fifty-six samples were collected from seven sites in the lake from July 2005 to May 2006. Samples were collected in each of four seasons, and included 28 surface sediment samples and 28 water samples. Sediment samples were analyzed for Fe, Pb, Ni, Co, Cu, Mg, K and Na. The results showed an increase in beach sediment pollution from summer to winter. Taxonomic analysis of phytoplankton samples revealed 102 taxa, including 56 Bacillariophyceae, 8 Chlorophyceae, 18 Dinophyceae and 20 Cyanophyceae. Chlorophyll *a* concentrations ranged from 0.3 to 26 $\mu g\ l^{-1}$, with the highest values during the winter and lowest values during the summer. These results suggest that beach sediment pollution is highest in the winter and, at the same time, the water quality conditions in El-Temsah lake favor oxidation conditions which maximize phytoplankton productivity. In contrast, sediment pollution and phytoplankton productivity are lowest during summer, which also corresponds to more alkaline water conditions. The images were rectified and analyzed by ERDAS IMAGINE 8.9. A 1968 topographic map and enhanced 2005 Landsat Thematic Mapper images (30 m resolution) were utilized to determine the coastline positions using ERDAS Imagine 8.9. Image processing techniques were applied using ENVI 4.2 to analyze the ETM+ image data. Image enhancement was applied. Image data was enhanced spectrally to verify surface water pollution detected from chemical and biological analyses and to detect the sources of untreated domestic, industrial and agricultural waste water. In general, the lake has been subjected to successive shrinking due to human activities, primarily through extensive building along the shoreline. The uncontrolled growth of cities is associated with seismic hazards, affecting on buildings and infrastructures, mostly due to

insufficient knowledge of earthquakes activity. Seismic epicentres were recorded along the Suez Canal from 1904 to 2006. Widespread moderate to micro earthquakes were identified around the western side of the lake, with scattered events along the eastern side. In general, water pollution in El-Temsah Lake has been mitigated over the last decade due to successive dredging and improved water treatment. Most of untreated water was discharged along the western side of the lake. The eastern part of the lake is less polluted and is, therefore, more suited for fishing, tourism, urban planning and navigation activities, although higher use of eastern portion of the lake could accelerate water and sediment quality deterioration in that region.

## 2. Introduction

El-Temsah Lake formed in a depression situated in a fault trough (Holmes, 1965 and El Shazley et al., 1974) covered with Nile Delta sediments. The trough originated tectonically as part of the "Clysmic Gulf" that represented the first stage of separation along the Red Sea-Suez Rift during the Late Oligocene-Early Miocene period (El-Ibiary, 1981). The lake covers about 15 $km^2$ between $30^0$ 32` and $30^0$ 36` north latitude and $32^0$ 16` and $32^0$ 21` east longitude, and is located near the middle of the Suez Canal, at a point 80 km south of Port Said. The depth of the lake ranges between 6 and 13 m. Following the construction of High Dam (completed in 1970), lake water quality changed from saline to fresh water due, to a large degree, to the precipitation of gypsum and mud lamina. The lake is the backbone of a tourism industry that attracts a large number of holiday visitors. In addition to the visitors, the tourism and fishing industries employ local citizens and provide a significant portion of the district revenues. Unfortunately, the increasing number of temporary and permanent residents has also created higher volumes of waste, including raw liquid and solid municipal sewage, agricultural runoff and industrial wastewater, all of which end up in El-Temsah Lake. The lake is also a sink for aliphatic and aromatic hydrocarbons originating from shipping activities including accidental and incidental oil pollution, ballast water release and general vessel and facility maintenance. In addition to hydrocarbons, several other potential chemical contaminants originate from various pollutant sources. The concentrations of Pb, Zn, Cu and Cd metals have been shown, for example, to be significantly higher in this area (Abd El Shafy and Abd El Sabour, 1995). Elevated nitrate and nitrite levels are due to the discharge of sewage, fertilizers and pesticides.

Through 1996, water quality along the northern and western boundaries of the lake has experienced substantial deterioration due to the rapid development of tourism projects and continuous waste discharge at Ismailia City (ETPS, 1995). In order to rejuvenate the lake, improve water quality and help re-establish the fishing and tourism industries, local authorities have embarked on a national program, using dredging to remove significant portions of contaminated lake sediment. Moreover, the re-evaluated assessment and mitigation of seismcity risk around any area, especially lake area is important due to the fast growing and developing of great and important constructions. The earliest attempts to review the seismicity and tectonic activity of the overall Suez Canal region were given by Aboulela, 1994. The main objective of the research described here was to assess the environmental status of El-Temsah Lake, focusing on heavy metal analysis of beach sediments and the distribution of phytoplankton. Furthermore, try to make main zoom on the seismicity pattern around concerned area.

The diversity and density of biological communities are impacted by the physicochemical characteristics of the ecosystem, including temperature, pH and dissolved oxygen (DO). In addition, any single species is inevitably impacted by the other species present within the system (Moss, 1998). Phytoplankton species, for example, are strongly influenced by water quality, act as the primary source of autochthonous organic material in many lakes and are the main food for many filter-feeding, primary consumers (Boney, 1989). Monitoring phytoplankton populations, therefore, is often used as a means of evaluating the health of fresh, brackish and saltwater ecosystems. Phytoplankton diversity generally shows substantial temporal variation. In the Suez Canal, 126 diatom species were recorded in the winter and summer from 1969-1971 (Dorgham, 1974); 102 species were identified in 1983 (Dorgham, 1985); 94 species were observed in 1991 (El-Sherief and Ibrahim, 1993). Because of the existing historical data on phytoplankton populations in the Suez Canal, the importance of phytoplankton to overall community structure and the sensitivity of phytoplankton to environmental perturbations, they were used as the biological monitor in this study. Earthquakes epicentres distribution occurred overall the study area and its surrounding were using by recently information recorded data. Geographical information system (GIS) techniques were used to integrate chemical, biological and seismicity data in order to evaluate current conditions and make recommendations for sustainable coastal zone management.

## 3. Methodology

### 3.1 Field sampling locations

Six study sites in El-Temsah lake were selected to assess environmental pollution (Fig. 1). Samples were collected during four seasons between June 2005 and April 2006 from the following locations: El-Taween, El- Fayrooz, the Bridge, El-Osra, El-Forsan, Beach clubs. Sediment appearance and composition was dark-gray to blackish, soft, silty sand at the western sites (El-Taween, El- Fayrooz , the Bridge, El-Osra and El-Forsan), but a lighter-colored sand at the eastern El-Temsah sites. During the field visits, it was noticed that the El-Taween area was subject to substantial dumping or leakage of industrial wastes from ships passing through the lake, as well as disposal of domestic wastewater from businesses, particularly clubs, along the shore. The El-Fayrooz and Bridge sites are located near the junction of a western lagoon and El- Temsah lake, and receive large quantities of domestic, agricultural and industrial wastewater. The El-Osra and El-Forsan sites, in the northern part of the lake, receive domestic wastewater. In contrast, the eastern part of the lake (Beach club-1 and Beach club-2) is characterized by much lower pollution exposure. From each of the seven sampling locations, sediment, water and phytoplankton samples were collected from the lake. Sediment was collected at plastic bags and was kept for a week in a fridge before analyses. Subsurface water samples were taken at all sites for phytoplankton identification and counting. Water samples for physico-chemical studies were collected in polyethylene bottles of one liter capacity, and laboratory analysis started within few hours from the time of collection.

### 3.2 Environmental analyses

#### 3.2.1 Water and sediment analyses

In the field, dissolved oxygen (DO), pH and temperature were determined. Water samples were analyzed for salinity, conductivity, nitrate and phosphorus, according to Standard Methods (APHA 1992). For analysis of trace metal concentrations, the 28 sediment samples were dried at 60$^0$C for one day, weighed, and then digested with hot concentrated acid under reflux conditions. Metal concentrations in all samples were determined by following the methods described by More and Chapman (1986).

#### 3.2.2 Biological investigations

Phytoplankton samples were preserved in 500 ml glass bottles with lugol's solution (Utermöhl's, 1958). The standing crop was calculated as the number of cells per liter. Qualitative analysis was carried out using the preserved as well as fresh samples. These were examined microscopically for the identification of the present genera and species. The algal taxa were identified according to the following references: Van-Heurck (1986), Prescott (1978), Humm and Wicks (1980) and Tomas (1997). Species richness (alpha diversity) was calculated for each phytoplankton algal group as the average number of species per season. Relative concentration and relative evenness were expressed according to the equations of Whittaker (1972), Pielou (1975) and Magurran (1988).

3.2.3 Seismicity pattern investigation

Seismicity activity occurred around the El-Temsah lake and its surrounding was assessed in this study using information on revealed recorded earthquakes. Seismicity data from 1904 to 2006 were supplied from the National Earthquake Information Center (NEIC), International Seismological Centre (ISC) and the Egyptian National Seismic Network (ENSN).

### 3.3 Remote Sensing and GIS analyses

Satellite remote sensing is a potentially powerful tool for detecting shoreline change. Enhanced Landsat Thematic Mapper images ETM-7 (30 m resolution) for 2004 (Figure 2) were geometrically corrected and digitized to extract vectors representing shoreline positions in 2004. ERDAS IMAGINE 8.9 (Leica Geosystems, Norcross, GA, USA) was utilized for digitizing and editing data input. The outline of El-Temsah lake in 2004 was compared to the topographic map in 1968. Arc GIS 9.2 (ESRI, Redlands, CA, USA) platforms were used to organize, analyze and manipulate available data and generate new data for heavy metal, seismic and biological analyses.

Image segmentation techniques were used to produce vector maps for the El Temsah coastline to detect the shoreline position and identify changes between 1968 and 2004. In this study, image registration was carried out using ERDAS IMAGINE 8.9. A second-order polynomial was used to provide an adequate transformation for registering a full Thematic Mapper scene to geographical coordinates.

Thematic Mapper band 7 (short-wave infrared) was used to produce a vector map of the shoreline. Image segmentation was used to delineate the land/sea boundary along the coastline. A segmentation approach was also necessary in order to compare the results with previous shoreline maps produced.

## 4. Results and Discussion

### 4.1 Metal analyses

Data collected during this study indicate that, in the summer, concentrations of Na, K, Fe and Mg are elevated along the western side of the lake at the Bridge and El-Taween sites (Fig. 2). Low levels were identified along the northeastern side, at the El-Forsan and Beach clubs (Table 1). Concentrations ranged from 9.03 to 28.9 ppm (Na), 2.28 to 10.47 ppm (K), 3.85 to 12.71 ppm (Fe) and 0.42 to 9.69 ppm (Mg). In autumn, concentrations of some metals, including Na, K, Mg, Fe and Co were higher along the western side of the lake, at the Bridge area. Concentrations ranged from 65.74 to 127.63 ppm (Na), 5.27 to 34.19 ppm (K), 6.01 to 32.71 ppm (Mg), 7.97 to 102.44 ppm (Fe) and 0.12 to 0.42 ppm (Co). Mg and Na levels were higher in beach sediments in the winter and spring than during either the summer or autumn, ranging from 841.5 to 2145.12 ppm (Na) and from 29.82 to 676.89 ppm (Mg). Levels of both K (10.4 to 27.12 ppm) and Fe (27.59 to 133.25 ppm) in winter-collected sediment were higher than in the summer. Spring sediment concentrations tended to be very similar to winter levels. The lowest metal concentrations were identified along the northeastern side of the lake; samples collected along the western perimeter had the highest levels in the spring. Concentrations ranged from 8.65 to 18.8 ppm (K), 17.54 to 72.98 ppm (Fe), 29.82 to 340.51 ppm (Mg) and 0 (below analytical detection) to 1.51 ppm (Co). The concentrations of Cu, Pb and Ni were negligible at all study sites.

In summary, the concentrations of metals, including common ions such as Na and Mg, were noticeably elevated along the western corner of the lake at El-Taween, El Fayroos and the Bridge, but declined in the northeastern corner at El-Forsan and the eastern beach clubs. High concentrations of Fe at the El-Taween and Bridge areas are likely due to the disposal of raw sewage from nearby housing, and the impact of industrial waste residues in the Suez Canal. In addition, high concentrations of Mn are most likely associated with agricultural sewage, as well as wastewater from substantial industrial activities associated with ship construction and maintenance.

### 4.2 Water quality

While average ocean salinity ranges from approximately 32 to 35 ppt, local salinity – particularly near shore - can vary according to freshwater input, evaporation and temperature. Low salinity (31.4 ppt) was recorded when the temperature was low (14.5°C) in the winter. Salinity reached a maximum value (44.9 ppt) during the summer when temperature was highest (31°C), (Table.2). Conductivity varied between 42 µmhos $cm^{-1}$ in the winter and 107 µmhos $cm^{-1}$ in the summer. Freshwater discharged from sewage treatment systems, untreated sources and nonpoint source runoff, enter the lake on the western side, causing a salinity decline (31.4 – 32.2 ppt); the highest salinity (44.9 – 44.8 ppt) was recorded on the eastern side. The pH values recorded in the lake tended to be somewhat alkaline (7.9 – 8.9) in the summer. Dissolved oxygen in the surface water fluctuated between 5.6 mg $l^{-1}$ at El-Osra in the summer, to 10.2 mg $l^{-1}$ at El Fayroos in the winter. Nitrate ($NO_3$-N) concentrations ranged from15.6 µg $l^{-1}$ at El-Taween to 130.4 µg $l^{-1}$ at El-Osra. $SiO_3$ – Si values fluctuated between 2.7 mg.$l^{-1}$ at El Forsan site and 6.8 mg.$l^{-1}$ at the beach clubs. Its highest values occurred in spring and the lowest values in autumn. The importance of silicate lies in its significance for the construction of the cell wall of diatoms. This element is not a limiting factor for diatoms in the lake. Willem (1991) reported dissolved silica content between 0.03 $mg.l^{-1}$ and 0.20 $mg.l^{-1}$as limiting level for diatom growth. High level of $PO_4$-P is attributed to eutrophication caused by waste and input of drain terminating in the lake along the western side. It reached its maximum value 29.6 µg.l at El Fayroos site in winter and its minimum value of 6.9 $\mu g.l^{-1}$ at the beach clubs during spring. The N:P ratio is an important water quality indicator which can significantly affect phytoplankton taxonomic structure in a lake. In El-Temsah lake it was quite variable, ranging from 1.07 at El Taween to 9.45 the beach clubs (Table 2). A low ratio of N:P contributes to eutrophication and excessive blue-green algae which is often caused by wastewater, particularly domestic, input (Knuuttila et al., 1994). In summary, the western and northern parts of El-Temsah lake subjected higher levels of water pollution from various domestic, industrial and agricultural sources, which result in less favorable water and sediment quality conditions than are found in the eastern portions of the lake.

### 4.3 Phytoplankton analyses

Phytoplankton algal community and hydrographic parameters were investigated at the same sites and during the same seasons. A total of One-hundred and two taxa have been identified. Most of them belong to Chlorophyceae (8); Bacillariophyceae (56); Dinophyceae (18); Cyanophyceae (20) were recorded. The result suggested the presence of phytoplankton continuum in the area with dispersion of some species in certain microhabitat conditions. The maximum occurrence of the total phytoplankton density (1788 & 1718 $cells.l^{-1}$) was recorded in winter at the El-Taween and El Fayrooz sites. The productivity was high for Bacillariophyta (60.2 & 59.5 %) and Cyanophyceae (19.3 & 19.7 %) which may be attributed to concentrations of $NH_4$ – N, $PO_4$ – P and $NO_3$ – N, $NO_2$ -N and relatively higher values of salinity (33.8-32.2 ppt). Where the species richness (Alpha Diversity) was ranged between 6.586 during summer and 14.287 in winter while relative evenness (H') was fluctuated between 1.684 in summer and 1.902 in winter while ( C ) value was measured as 0.015 in winter and 0.033 in summer. Chlorophyll- a varied from 0.3 $\mu g.l^{-1}$ at the El-Taween to 26 $\mu g.l^{-1}$ at the El-Fayrooz sites. It exhibited high values during winter, while the lowest one during summer**.** The N:P ratio in the El Temsah Lake ranged between 1.07 and 9.45. The lowest value occurred due to eutrophication caused by wastewater and domestic input into the lake. Abundance of phytoplankton species may be attributed to High $PO_4$ lower water temperature; $NH_4$–N and $NO_3$–N were relatively high**.**

Phytoplankton biomass in the El-Temsah water samples was higher during the winter; the lowest values were observed during the summer. A total of 102 taxa were recorded, including Chlorophyceae (8), Bacillariophyceae (56), Dinophyceae (18) and Cyanophyceae (20). Species richness (Alpha Diversity) varied from 4 to 7% during the summer and 19 to 20% in the winter (Fig. 2). Maximum phytoplankton density (1788 cells $l^{-1}$) was recorded in the winter in the western side of the lake.

## 5. Risk Assessment using GIS

Image data extracted through remote sensing techniques were integrated with data collected from topographic and morphologic maps in order to monitor urbanization along the El-Temsah lake perimeter from 1968 to 2004. Shoreline changes were monitored using vector data, analyzed by image segmentation and growing techniques. Vector data indicated shrinking at the boundary of El-Temsah Lake due to human activities, including construction of roads, buildings and recreation centers (Fig. 3). Regulations mandate that development and urban projects constructed along the coastal zone of El-Temsah include assessment studies to enhance the economic viability of the projects and to protect the environment. The quantitative assessment of heavy metals in beach sediments is considered an important tool to trace anthropogenic pollution that affects water quality (Guerrin et al., 1990). A thick layer of sludge has accumulated in the near-shore lake sediments due to the disposal of multi-source wastes. Historical chemical and biological data clearly indicate that El-Temsah lake is suffering from significant human-related pressures, resulting in substantial water and sediment contamination from heavy metals, petroleum hydrocarbons, pesticides and general wastewater contaminants, thus making it a primary candidate for periodic dredging. Seismicity data was plotted on a map overall study area and its surrounding representing the magnitude variations (Fig. 4 A). Recent Epicentres distribution pattern show widespread micro to moderate earthquakes ($3 \leq Mb \geq 5.4$) along the western side, with scattered events on the eastern side, all of which could affect the various settlement projects. Hazards assessment maps indicate a positive relationship between the spatial distribution of heavy metals in beach sediments and biological assessment parameters, suggesting the health of phytoplankton populations (and other organisms through food-web linkages) is intimately connected to the degree of water pollution in the El-Temsah coastal zone.

## 6. Conclusion

Heavy metal analyses were conducted to determine the concentrations of Fe, Pb, Ni, Co, Cu, Mg, K and Na in beach sediments. The results show a temporal increase in levels from summer to winter: 4-22 ppm to 27-71 ppm (Fe), 0.5-10 ppm to 91-677 ppm (Mg), 2-10 ppm to 15-27 ppm (K) and 9-29 ppm to 1650-1850 ppm (Na). The need for mitigation of higher contaminant levels is indicated along the western border of the lake, including the Bridge, El-Fayrooz and El-Taween, due to the disposal of irrigation drainage water. The El-Fayrooz club area is apparently less polluted than the El-Taween and Bridge sites, probably because it is further away from areas where agricultural sewage enters the lake. Chemicals and biological analyses during the 2005-2006 study period indicate that the most appropriate zones for activities such as swimming, fishing and general water-related recreation are along the eastern and north eastern parts of the lake during the summer and spring. The El-Taween club in the southwestern corner of the lake was also found to be one of the least polluted areas in the autumn. Increased recreational and industrial activities in the areas that currently have better water and sediment quality, however, could lead to accelerated environmental degradation.

Concentrations of Mg and Na were highest in the winter and spring. These data indicate that lake conditions in the winter are conducive to increased phytoplankton productivity, as well as higher beach sediment pollution under acidic condition. In contrast, sediment pollution and phytoplankton productivity are lower during the summer and the lake water tends to be more alkaline. Abundance of Chlorophyceae, Bacillariophyceae and Cyanophyceae increase from the summer to the winter, as do dissolved oxygen, nitrate and (not surprisingly) chlorophyll *a* concentrations. Epicentres distribution pattern show widespread micro to moderate ($3 \leq Mb \geq 5.4$) earthquakes around the western sides, and scattered events along the eastern side of the lake as shows in Fig.4 A and B. Integrated GIS was used to construct land use and hazards maps of the study area. The eastern portion of the lake, because of lower pollution levels, is the most appropriate site for fishing, tourism, urban planning and navigation. Fortunately, environmental pollution has shown a decline over the last decade due to successive sediment dredging and improvements in water purification systems.

Figure 1 (A) Location of El-Temsah Lake in the Suez Canal. (B) sample locations within El-Temsah Lake .

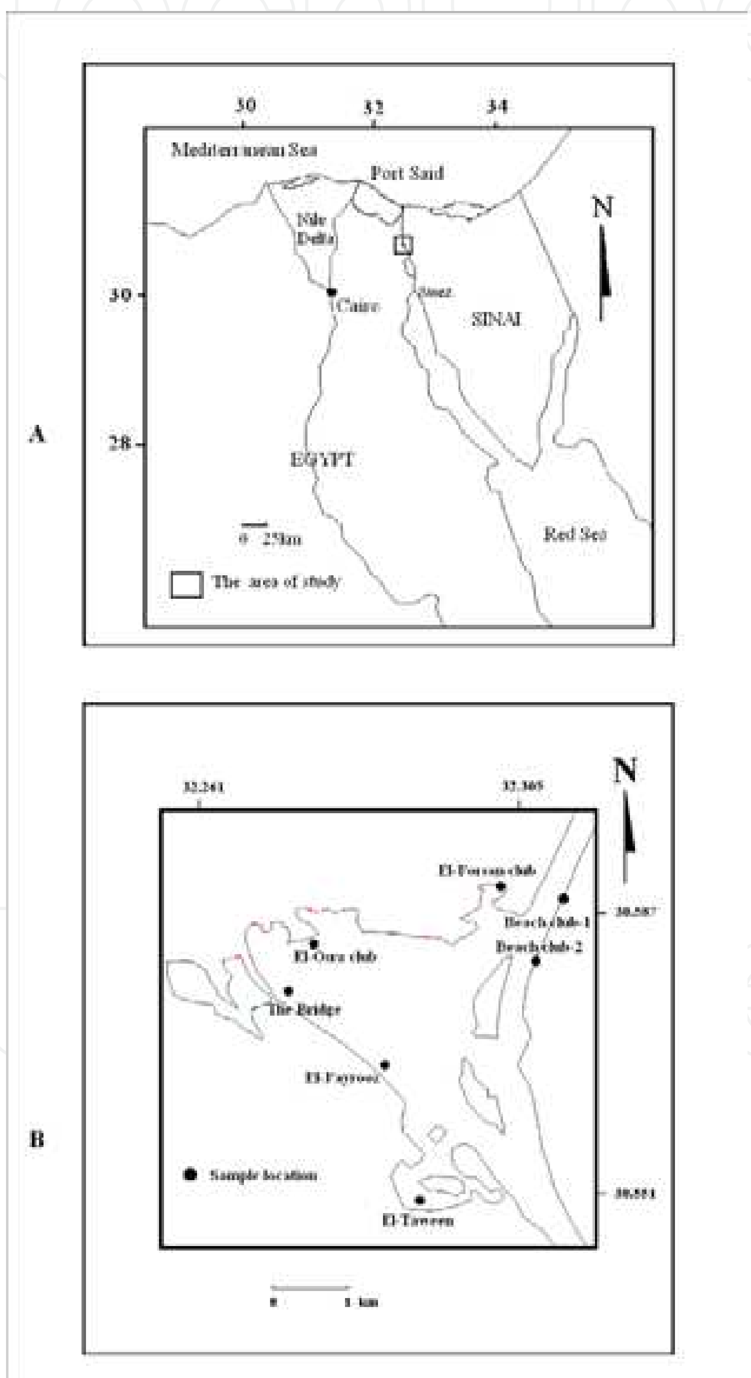



Fig 1. (C) Landsat image for year 2004 of the Suez Canal District.

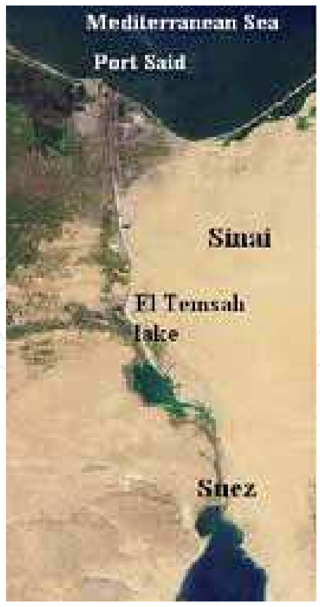



Fig 2. Enhanced Landsat Thematic Mapper images ETM-7 for year 2004 of the El-Temsah Lake

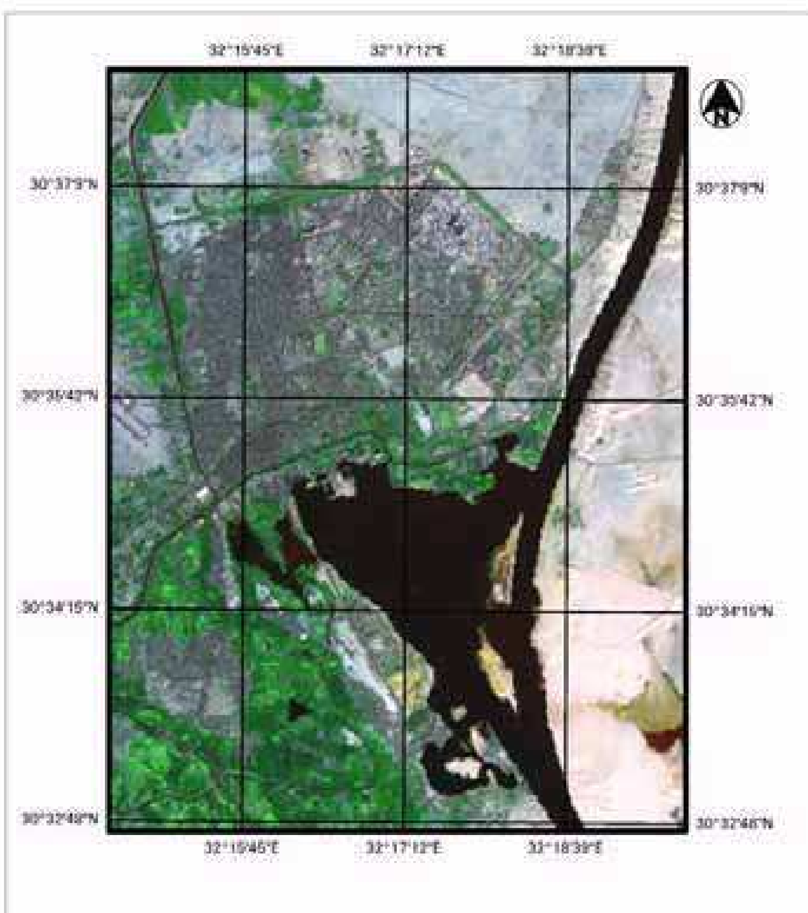


Fig 3. Concentrations of metals in beach sediments during the summer and winter

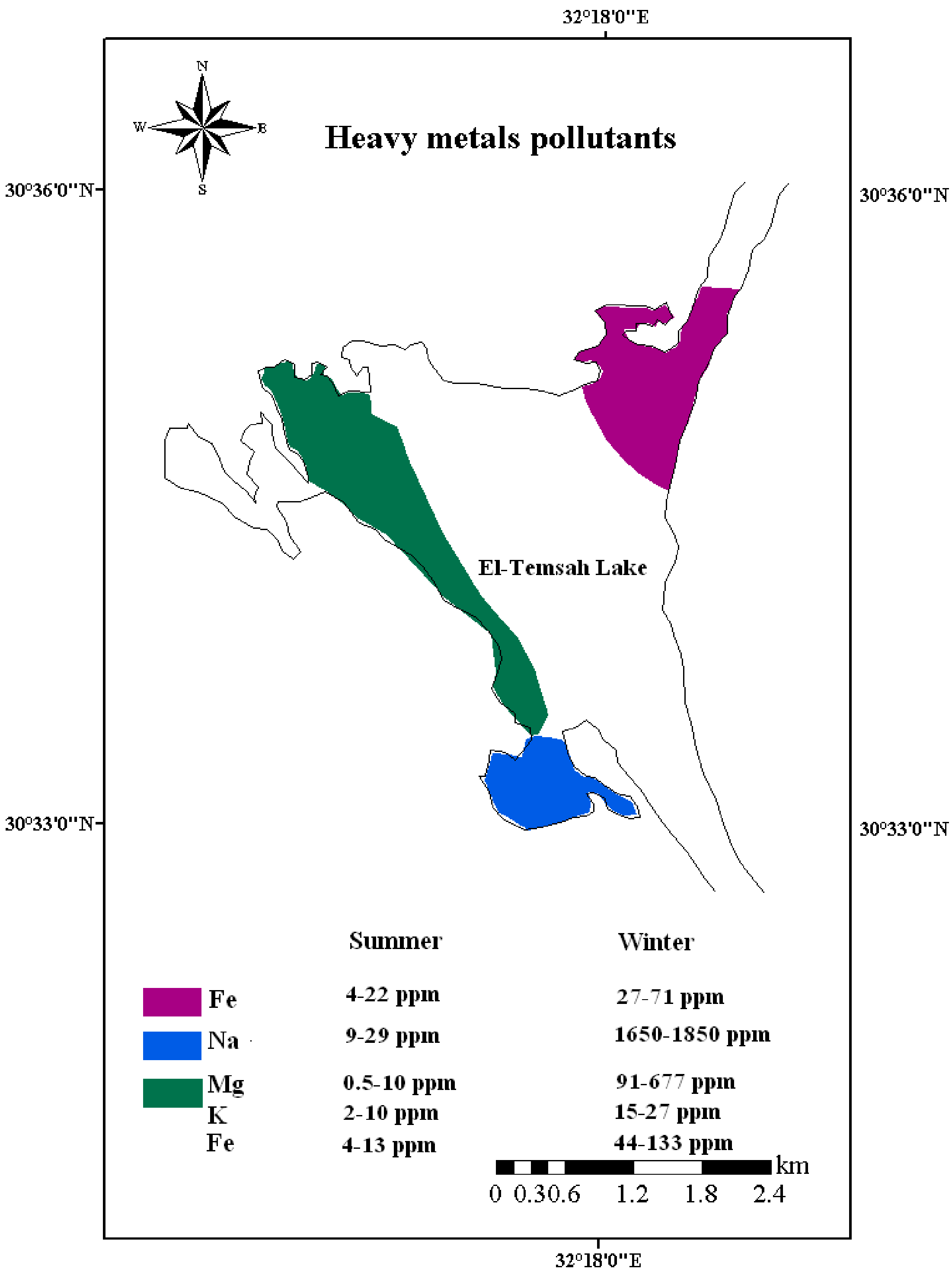



Fig 4. Phytoplankton species richness (Alpha Diversity) in El-Temsah lake during the summer and winter

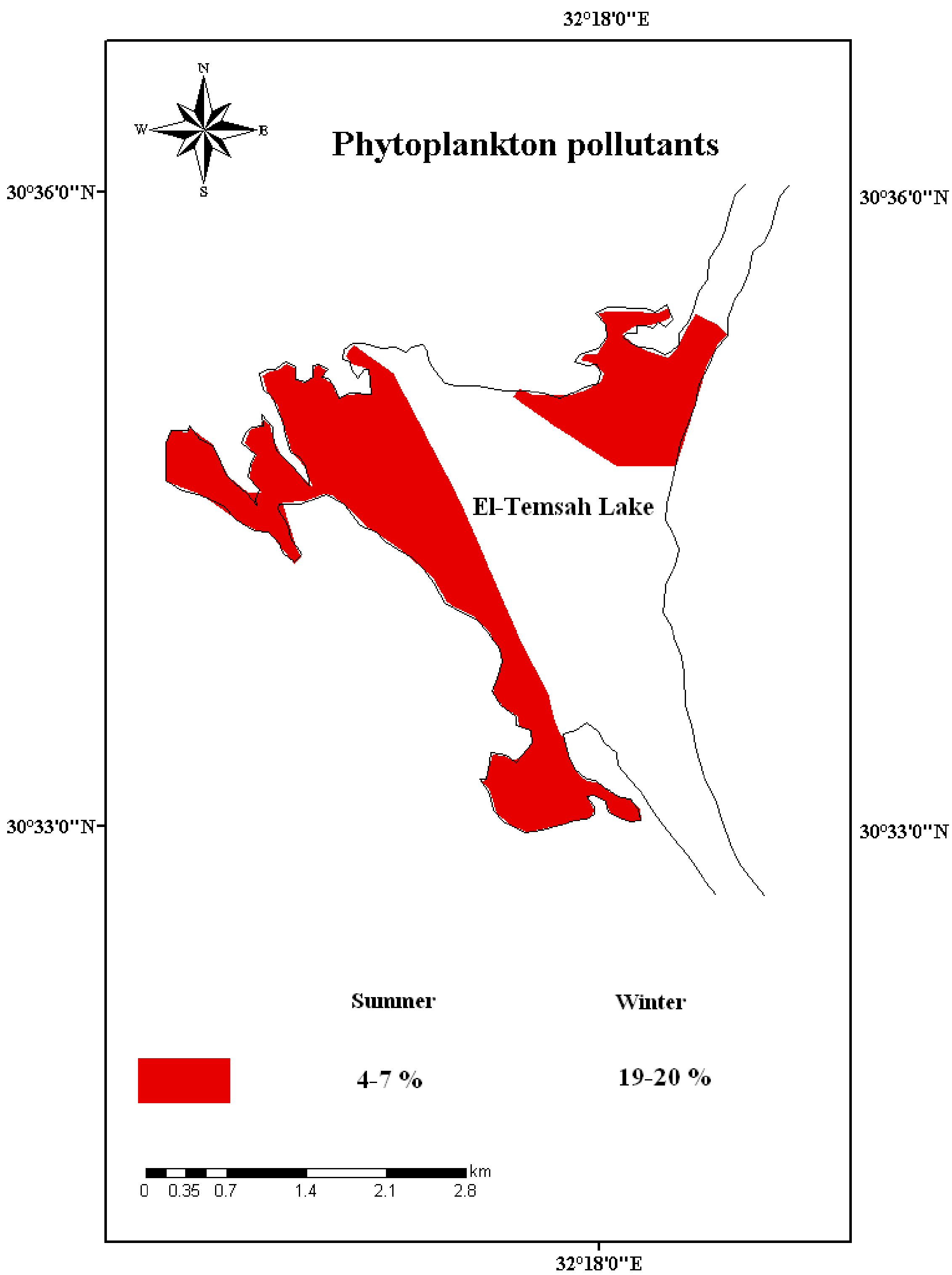



Fig 5. Locations of activities affecting the boundaries of El-Temsah lake

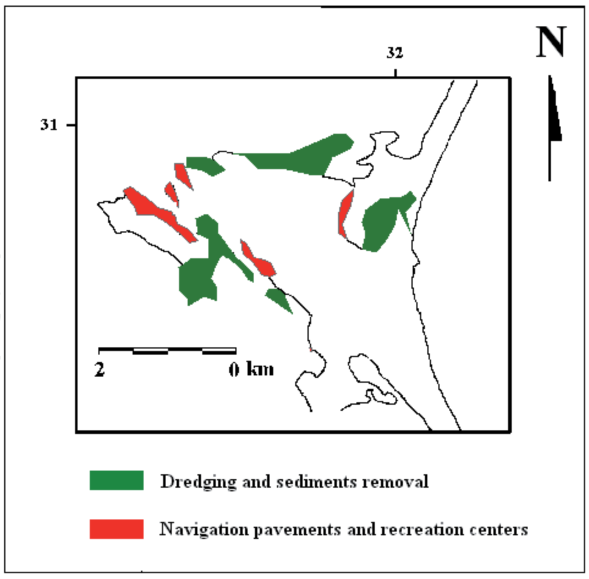
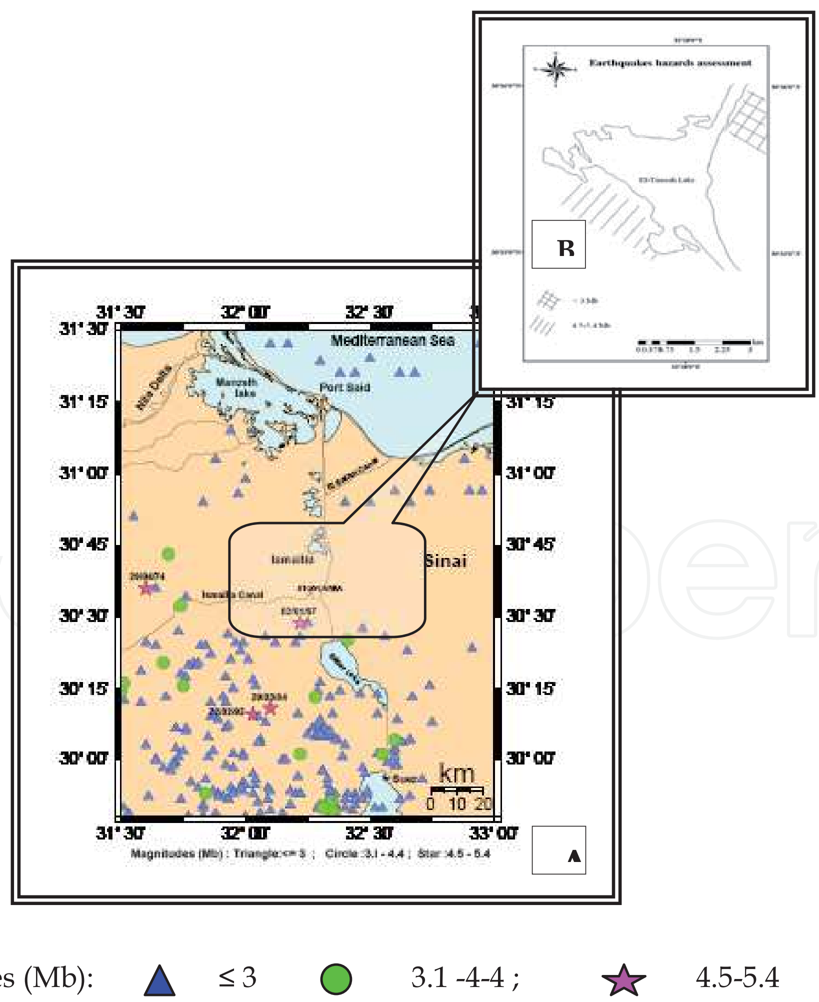



Fig 6. (A): Map showing distribution of recently local and regional recorded earthquakes with magnitude (3.0 ≤ Mb ≥ 4.5) of the study area and its surroundings. (B): Earthquake hazards assessment map of El-Temsah lake.



| | Na (ppm) | K (ppm) | Fe (ppm) | Mg (ppm) | Co (ppm) |
|---|---|---|---|---|---|
| **Sample No.** | Summer | Summer | Summer | Summer | Summer |
| El-Taween | 28.910 | 4.82 | 6.06 | 4.12 | 1.51 |
| The Bridge | 26.800 | 6.7 | 11.5 | 5.8 | 1.46 |
| El Fayrooz | 27.470 | 10.47 | 12.71 | 9.69 | 1.29 |
| El-Osra | 9.030 | 2.28 | 3.85 | 0.42 | 0.21 |
| El-Forsan | 14.450 | 3.87 | 6.71 | 4.28 | 0.21 |
| Beach clubs | 22.050 | 7.29 | 7.48 | 2.49 | 0 |
| | | | | | |
| **Sample No.** | Autumn | Autumn | Autumn | Autumn | Autumn |
| El-Taween | 65.74 | 5.27 | 7.97 | 6.01 | 0.25 |
| The Bridge | 95.74 | 20.5 | 90.89 | 19.8 | 0.35 |
| El Fayrooz | 113.12 | 34.19 | 102.44 | 23.67 | 0.42 |
| El-Osra | 127.63 | 24.42 | 42.81 | 20.76 | 0.17 |
| El-Forsan | 93.78 | 10.91 | 31.05 | 32.71 | 0.12 |
| Beach clubs | 105.39 | 20.49 | 39.4 | 17.08 | 0.12 |
| | | | | | |
| **Sample No.** | Winter | Winter | Winter | Winter | Winter |
| El-Taween | 1655.88 | 17.75 | 44.14 | 676.89 | 0.17 |
| The Bridge | 1780.9 | 21.5 | 98.9 | 357.9 | 0.1 |
| El Fayrooz | 1844.05 | 27.12 | 133.25 | 153.72 | 0.17 |
| El-Osra | 1731.15 | 15.41 | 60.69 | 91.75 | 0.13 |
| El-Forsan | 2145.12 | 25.23 | 71.73 | 349.29 | 0.04 |
| Beach clubs | 1806.42 | 10.4 | 27.59 | 57.14 | 0 |
| | | | | | |
| **Sample No.** | Spring | Spring | Spring | Spring | Spring |
| El-Taween | 841.5 | 11.25 | 25.1 | 340.51 | 0.84 |
| The Bridge | 870.87 | 15.89 | 69.99 | 245.89 | 0.5 |
| El Fayrooz | 935.5 | 18.8 | 72.98 | 80.21 | 0.73 |
| El-Osra | 870.2 | 8.85 | 32.27 | 46.09 | 0.17 |
| El-Forsan | 1079.5 | 14.55 | 39.22 | 176.79 | 0.13 |
| Beach clubs | 914.6 | 8.65 | 17.54 | 29.82 | 0 |

Table 1. Heavy metal analyses result of water samples collected at El-Temsah Lake during summer 2005-spring 2006

| Sites | El-Taween | | El Fayrooz | | The Bridge | | El Osra | | El Forsan | | Beach clubs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Temperature °C | 14 | 29 | 14 | 29 | 14.5 | 29.5 | 14.5 | 29.5 | 15 | 31 | 15 | 31.5 |
| pH | 7.4 | 8.5 | 8 | 8.8 | 8.6 | 8.9 | 7.9 | 8.4 | 7.3 | 7.9 | 7.2 | 7.9 |
| Conductivity μmohs.cm$^{-1}$ | 42.5 | 52.5 | 51.5 | 78 | 77 | 85 | 42 | 67.1 | 68 | 107 | 79 | 90.2 |
| Salinity ppt | 33.8 | 41.9 | 32.2 | 44.6 | 33 | 43.8 | 31.4 | 42.7 | 41.2 | 44.9 | 39.9 | 44.8 |
| Turbidity m | 2.6 | 2.9 | 2.8 | 2.9 | 2.2 | 2.6 | 1.8 | 2.4 | 0.24 | 0.45 | 0.39 | 0.5 |
| Dissolved Oxygen mg.l$^{-1}$ | 7.2 | 8.4 | 7.3 | 10.2 | 6.2 | 8.9 | 5.6 | 9.6 | 6.3 | 9.8 | 7.1 | 8.8 |
| Nitrate μg.l$^{-1}$ | 15.6 | 114.1 | 29.5 | 130 | 53.2 | 112.2 | 32 | 130.4 | 32.2 | 98.4 | 28.2 | 92 |
| Nitrite μg.1-1 | 2.7 | 25.2 | 1.4 | 19.2 | 1.3 | 22.1 | 1.1 | 19.1 | 1 | 10 | 1 | 13 |
| Ammonium μg.l$^{-1}$ | 118 | 253 | 121 | 188 | 115.3 | 159.3 | 112 | 157.2 | 98.3 | 148 | 92.2 | 134.9 |
| Phosphate μg.l$^{-1}$ | 13.2 | 20.4 | 12.2 | 29.6 | 13.7 | 28.5 | 10.5 | 26.2 | 12.2 | 26.8 | 6.9 | 25.9 |
| Silicate mg.l$^{-1}$ | 3.4 | 6.6 | 3.8 | 6.4 | 3.3 | 5.8 | 3.1 | 5 | 2.7 | 6.7 | 3.4 | 6.8 |
| Chlorophyll a μg.l$^{-1}$ | 0.3 | 24 | 2.8 | 26 | 3.2 | 18.1 | 4.2 | 16 | 3.9 | 17.9 | 4.7 | 19.3 |
| N: P ratio | 1.07 | 5.59 | 1.8 | 5.82 | 2.8 | 4.75 | 2 | 6.74 | 1.98 | 4.8 | 2.03 | 9.45 |

Table 2. Physicochemical parameters of water samples collected at El Temsah Lake during summer 2005-Spring 2006

## 7. References

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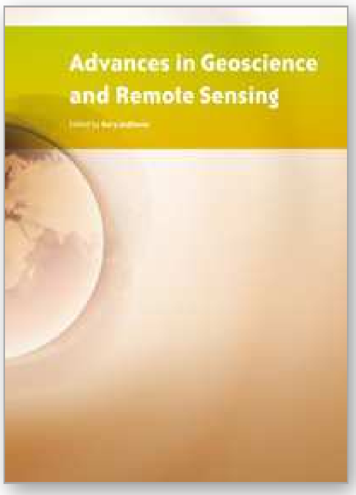


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Remote sensing is the acquisition of information of an object or phenomenon, by the use of either recording or real-time sensing device(s), that is not in physical or intimate contact with the object (such as by way of aircraft, spacecraft, satellite, buoy, or ship). In practice, remote sensing is the stand-off collection through the use of a variety of devices for gathering information on a given object or area. Human existence is dependent on our ability to understand, utilize, manage and maintain the environment we live in - Geoscience is the science that seeks to achieve these goals. This book is a collection of contributions from world-class scientists, engineers and educators engaged in the fields of geoscience and remote sensing.