Marine Pollution in the Gulf of Aqaba and Gulf of Suez and its Effects on South Sinai
A Comprehensive Review

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1. Overview

The Red Sea and its gulfs, Gulf of Aqaba and Gulf of Suez, constitute a unique ecosystem with high biological diversity. Their natural resources provide a substantial economic support for the region. The Red Sea resources contribute substantially to Egypt's economy, particularly in the areas of oil production, navigation, tourism and fisheries. This report presents a comprehensive review of the data available at EEAA regarding marine pollution in the Gulf of Aqaba and the Gulf of Suez insofar as they affect South Sinai. A brief description of the geography and the specifics of the Red Sea, Gulf of Aqaba, Gulf of Suez, and South Sinai, are first outlined, with more detail provided on the oceanographic and meteorological conditions of the gulfs. Activities generating pollution, whether marine-based (e.g. shipping activities and inshore oil production), land-based (e.g. tourism and industrial activities), or due to natural causes (e.g. floods) are identified, together with a detailed account on the sources and levels of pollution that exist. The adverse impacts and environmental degradation imposed by such pollutants on the marine environment and South Sinai are addressed, along with some of the initiatives and recommendations considered for remedial action in mitigating such adverse effects.

2. Background

2.1 Red Sea, Gulf of Aqaba, Gulf of Suez, and South Sinai

The Red Sea is a long, narrow body of water separating northeast Africa from the Arabian Peninsula. It is nearly 2000 km of navigable waters connected at the south with the Indian Ocean, and joins the Mediterranean Sea at the north of the Gulf of Suez. The Red Sea is 1932 km long and averages 280 km in width, and is shared by Egypt, Sudan, Ethiopia, Republic of Yemen, Saudi Arabia, Jordan and Israel. It is a semi-enclosed, narrow water body with no river inputs. The area of the Red Sea is about 437,970 km$^2$ and its mean depth is 491 m. In the north the width is only 175 km but southward it increases to a maximum of 370 km near Jizan, then decreases to 30-40 km at Bars El-Mandab. The deeper basin of the Red Sea is separated from the Gulf of Aden by shallow channel shoals about 100 m deep, off Hannish Island. The Red Sea is valuable, not just as a unique environment, but as one of a high diversity, great scientific and ecological sensitivity and of great beauty and tourist-value. Sadly, it has a fragile environment and, since all nations directly or indirectly make commercial use of its waters, then all nations, not just those bordering its shores, should contribute to its protection and preservation. It is an environment for future generations to use, study and enjoy.

The Gulf of Aqaba in the northern Red Sea is a warm water body, approximately 180 km long and on average 8 km wide, and attains a depth of about 1355 m. It is a deep basin with narrow shelves, which comprises two isolated depressions separated by a submarine sill. The northern depression is about 1,100 m deep and the southern depression is about 1,420 m deep. The maximum depth within the Gulf of Aqaba is observed near the east coast with a depth of 1,829 m. The Gulf of Aqaba is a marine environment enclosed by arid lands that experience extremes of temperature and exceedingly low levels of precipitation. These conditions have led to the evolution of unique, and hence internationally important, coral reef and marine ecosystems, which are particularly susceptible to damage from pollution or other
forms of environmental impact. The Gulf of Aqaba also represents a natural resource of major economic significance to the four riparian countries (Egypt, Israel, Jordan, and Saudi Arabia) in terms of access to sea transportation and the development of tourism and other industries along its shores.

The Gulf of Suez is relatively shallow, with a maximum depth of about 64 m; outside its mouth the depth drops sharply to about 1255 m. In contrast, the Gulf of Aqaba attains a depth of about 1355 m and is separated from the deep waters of the Red Sea by an entrance less than 100 m deep. The Gulf of Suez has a relatively flat bottom with a depth ranging between 55 and 75 m. Hence, the Gulf spreads a shallow basin filled with the surface water of the Red Sea. The Gulf of Suez is the area the most at risk of pollution in the Red Sea, particularly oil pollution.

Sinai Peninsula is a strategic national security zone for Egypt. Sharm El-Sheikh area, located at the southern part of Sinai, was declared as a protected area because of the diversity of wildlife species and other available natural resources. Sharm El-Sheikh area is characterized by barren terrain with limited vegetation cover, diversity of landscapes, clear skies and clear water with shallow coral reef community. The entire Sinai region is deeply dissected by the river valleys (or wadis) that eroded at earlier geological periods. These river valleys break the surface of the plateau into series of detached massifs with a few oases scattered here and there. Sinai is a triangular peninsula, the base points to the north and it's apex to the south. Most lowlands slope gently towards the Gulf of Suez, the lowest forms the El-Qaa coastal plains. In the southern zone, the mountains come close to the sea forming a bold and rocky coastline that runs into the Gulf of Aqaba. The Sinai coastline varies among alternating high mountains, hills and fine-grain yellow sand beaches. The natural wealth of the Sinai region is characterized by internationally recognized coral reefs, clear warm coastal waters, outstanding desert landscapes, sites of cultural and religious importance, and near permanent sunshine. Those resources, coupled with their proximity to European tourism markets, have stimulated the rapid growth of tourism development that the region is currently experiencing.

2.2 Oceanographic and Meteorological Conditions in Gulf of Aqaba and Gulf of Suez

Oceanographic and meteorological conditions in the Gulf of Aqaba and Gulf of Suez is described here before proceeding to investigate the marine pollution in the gulfs. For lack of general data on the meteorological conditions in Sinai, the data available for Sharm El-Sheikh is taken to be representative of the conditions in South Sinai.

**Air Temperature:** The climate is arid, with a yearly average net evaporation of 1 cm/day. The monthly variations of air temperatures of Sharm El-Sheikh region, generally varies from 17.8°C to 20.3°C in winter, from 24.1°C to 31.7°C during spring, from 31.5°C to 32.7°C during summer, and from 20.4°C to 26.8°C during autumn.

**Relative Humidity:** The maximum values of humidity vary from 54.6% to 63.5% in the winter months (November to April), which is a relatively high relative humidity. In the summer months; from May to October; the maximum values of humidity vary from 47.5% to 55.6 %, showing that the summer months are more arid.

**Winds:** Winds blow mainly from the north-northwest direction throughout the year. Winds also reach the area from other directions but with lower frequency; from April to October,
winds are prevailing either from southeast or northeast direction. From November through March, winds swing less frequently from east to west beside the dominant northern winds.

Cloud Cover: The Red Sea is a very unclouded area. The cloudiest months are from December to March when more than one-quarter cover is to be expected for 30-40% of the time. For the rest of the year cloud cover is very small, 10-20%, with long cloudless period from June to September.

Rainfall: Rainfall in the region is extremely sparse and localized. The rain is mostly in the form of showers of short duration, often associated with thunderstorms and occasionally with dust storms, resulting in poor visibility. Over the Gulfs of Suez and Aqaba, showers are very infrequent. All of the rainfall in the region occurs within just a few days, mostly in December; during some years none falls. Measured during a 20-year period, the average annual rainfall was about 25 mm for the Gulf of Aqaba. Climatological studies of the area document the large deficit between the amount of precipitation and evaporation. Rainfall at the northern end of the Gulf of Aqaba is normally 22 mm per year. Evaporation is 179 mm, eight times precipitation, leaving a deficit of 157 mm per year. Inflow of waters from the Red Sea balances the deficit.

Tide: The physiographic configuration of the Red Sea, and the Gulf is long, narrow and an almost closed embankment, dictate the nature of the tides. Tides are semi-daily and their characteristics differ in the two Gulfs. In the Gulf of Suez, a nodal point occurs near El-Tur about 180 km north of the southernmost limit of the Gulf. The tidal range in the Gulf of Suez, near its northern limit, is about 2 m, decreasing southward to 0 m at El-Tur and increasing again up to about 60 cm near Ras Mohammed. The tidal range in the Gulf of Aqaba is about 70 cm at Taba and 90 cm near Sharm El-Sheikh. No nodal point exists along the Gulf of Aqaba. The groundwater levels are very dependent on the tidal range in the sea level because the materials underlying the supra tidal zone are very permeable. In summer, evaporation causes the water level to sink a maximum of 10 cm, and more seawater is supplied. In winter, with decreasing evaporation less seawater is supplied even though the winter tides run much higher than the summer tides. It has been observed that the water level rise in winter occurs rather quickly (within a few days). This is due to a sudden rise in tidal levels all along the Red Sea and the Gulf of Aqaba in fall. This phenomenon is not related to the tides themselves, but to the climatic responses (e.g. monsoons) to the movement of the sun around the equinox.

Land and Sea Breezes: As in all coastal areas prone to strong solar heating, the shores of the Red Sea, like in Sharm El Maya and Naama Bay shores, experience diurnal wind changes commonly referred to as land and sea breezes. The sea breeze, a flow of air from the sea towards the land, develops during day light hours, usually reaching maximum strength in early or mid afternoon. The reverse flow, land breeze, occurs at night but most strongly developed around dawn. In the absence of other factors, land and sea breezes tend to flow more or less at right angles to the shoreline.

Water Movement and Current: The fundamental movements of surface water follow the winds, so that the northerly wind of summer drives surface water south for about four months at a velocity of 12-50 cm/sec, while in winter, the flow is reversed, pushing water into the northern Red Sea from the southern part; the net value of the latter movement is greater than
the summer current to the north, and the drift continues to the northern end of the Gulf of Suez. The main surface drifts are slow moving and are easily modified and even reversed by local effects and by small tides.

Although south-flowing currents, generated by the prevailing northern winds, exert a major force that affect the sea marginal depositional environments, other northward-moving currents in the southern parts of both gulfs counteract this influence. These northward-flowing currents include currents resulting from salinity differences. A warm less saline surface water current flows into the gulfs from the Red Sea replacing waters lost by evaporation and lost by an outflowing deeper density current of more saline cooler waters. Stormy winds from the south at the tip of the Sinai Peninsula drive currents northward in both gulfs.

The common storms in the Gulf of Aqaba accompanied by winds of up to 45 to 80 knots provide considerable bursts of energy to these currents. Because some of the high winds are southerly, especially in winter, one can expect to find the normal long shore current's flow to be temporarily reversed. Currents in the southern part of the gulf are most affected by strong southerly winds. Oceanic currents in the Indian Ocean change the level of the Red Sea and the gulfs seasonally. The effects in both gulfs are sea levels that are about 30 cm higher in winter than in summer.

Water temperature: The water temperature is lower in the northern parts than in the southern part of the Red Sea. Sometimes, sudden changes of temperature occur from one area to another, especially in the central part of the area. This change may reflect the natural barriers that prevent free mixing of waters in the area and thus inhabiting regular changes. The Gulf of Suez water affects the northern and western side of the Red Sea down to 200m in depth. Surface temperature declines slightly towards the entrance of the gulfs, owing to the influx of cooler water from the Gulf of Aqaba, and there is also a gradual decrease of temperature in the northerly direction. The mean annual maximum and minimum water temperatures of the coast of the Gulf of Aqaba are higher than those of the Gulf of Suez.

In Sharm El-Sheikh area the surface water temperature in summer (June 1996) showed a variation from 25.5°C to 27.3°C, with an average of 26.1°C. In winter (February 1997) the temperatures were lower than that of summer showing less variability at the surface, ranging from 22.6°C to 23.2°C, with an average of 22.9°C.

Salinity: The salinity gradient in the Gulf of Suez is five to six times greater than the values recorded for the Red Sea or Gulf of Aqaba. The distribution of surface salinity in Sharm El-Sheikh lagoons showed values from 40.2% to 40.7%. Salinity show limited variation in spite of the presence of desalination plants in Naama and Sharm El-Maya Bays, but it seems to be with negligible effect. In Port Bay, the salinity distribution showed an increase in the North West direction indicating the effect of land drainage resulting from human activities in this area.

There is considerable evidence that, in a given latitude, salinities are higher on the western side than in the east so that isohalines are aligned generally from north-north east to south-southwest. The difference between the two sides in the same latitude sometimes amounts to as much as 1%.

The inflow current from the Red Sea at surface is a less saline, whereas the more saline (denser) waters, resulting from the large evaporation precipitation ratio, sinks and forms a counter flow to the south. A sill at the Strait of Tiran (depth 252 m) separates the Gulf of Aqaba from the Red Sea and restricts deep circulation. The salinity increases from south to north in the Gulf of Aqaba (40% to 42%). Low winter and high summer values of salinity are observed. High values (greater than 41%) in August, and low values (40.3%) in March.
**Dissolved Oxygen:** The measured dissolved oxygen concentration in the surface water of the Red Sea is near to saturation values. The saturation values are in the range of 4.8 to 6.5 ml of oxygen per liter depending on temperature and salinity values. The saturated layer in the Red Sea extends to about 100 m depth. Below 100 m in the Red Sea, the dissolved oxygen concentration values drop to only 10 – 25% of the saturation values. The Gulf of Suez resembles the Gulf of Aden in this and in many others of its characteristics, and has no oxygen minimum, while in the Gulf of Aqaba, there is a gradual decline with depth but never to lower than about 50% saturation. The dissolved oxygen in the water of Sharm El-Shiekh area showed more or less homogeneous distribution. However, the oxygen content at 100 m layer was significantly lower in spring, yet still indicating a well oxygenated condition (5.3 mg/l).

Horizontal distribution of dissolved oxygen concentrations in summer at the surface of the lagoons in Sharm El-Sheikh showed values ranging from 4.32 to 4.77 mg/l, and from 95.53% to 107.63% saturation. In winter, oxygen distribution showed higher values (5.32 – 5.66 mg/l) than that of summer, which may be attributed to lower temperatures. Super-saturation of oxygen values is shown in Sharm El-Maya Bay in summer due to photosynthetic activity.

**Acidity/Alkalinity (pH):** The distribution of pH values at the surface water in summer showed values ranging from 8.25 – 8.42 reflecting low variation. In winter, pH values were lower than that recorded in summer with a variation range of 8.0 to 8.18. The observed higher pH values at surface water in summer could be attributed to the photosynthetic activity due to higher temperature and long light span.

**Nutrients:** Most of the Red Sea water has been considered oligotrophic with the exception of small areas off the Sinai Peninsula. The upper waters of the Red Sea are nutrient-poor, with nitrate being depleted more than phosphate. High levels of nitrite and ammonia have been recorded in the upper waters, which can be considered as an indicator of high bacterial activity. Seasonal variations occur in dissolved nutrient concentrations near shore and that local eutrophication is resulting from anthropogenic inputs. Water in the Gulf of Aqaba and Gulf of Suez is poor in nutrients compared with the Indian Ocean.

3. **Environmental Threats from Pollution-Generating Activities and Natural Causes**

The information presented in this section is compiled from various sources of material. For the activities imposing environmental damage in the Gulf of Aqaba, specific data is available for Ras Mohamed, Sharm El-Sheikh, Nuweiba, Dahab, Eilat, and Taba. Similarly, for the Gulf of Suez, some relevant data was made available by references to Lake Timsah, Suez Canal, Suez Bay, Suez Harbour, Port Tewfīq, Zeitia, Suez City, and Ain Sukhna. In general, the pollution-generating activities in the Gulf of Aqaba were easily accessible, and more pertinent to the South Sinai area than that which was available for the Gulf of Suez.

3.1 **Gulf of Aqaba**
The Gulf of Aqaba’s environmental problems are primarily induced by tourism and associated activities as well as maritime traffic, which result in marine, aquifer, soil, and noise pollution, and destruction of coral reef and desert ecosystems. In addition, environmental issues, which are related to the management of wastewater and solid waste, are exacerbated by the increasing resident population of the coastal cities and the numbers of tourists visiting the area. Human impact on the environment can be summarized into seven broad categories, as follows: tourism, ship-based activities, wastewater management practices, solid waste management practices, ferry traffic, marine aquaculture, and cruise-boating. Environmental threats from natural causes are also of concern and can be categorized into floods and southern winds.

3.1.1. Tourism

An estimated 500,000 tourists visited the Gulf of Aqaba coastal zone in 1996 and more than 3 million are expected in 2017. The relatively rapid growth of tourist visitation since the late 1980s has spurred interest in further development of tourism as an additional source of foreign income. Environmental concerns relate to the impact that these developments and the increase in numbers of tourists will have on the resources that tourists visit the Aqaba coast to enjoy.

The most rapidly growing threat in the region is from tourists, who are drawn to the continual bright sunshine, high temperatures, sandy beaches, and spectacular diving opportunities. The potential for tourism had always existed in the region, but had been thwarted by decades of hostilities and political conflict. Sites like Ras Mohammed attract divers from around the world, while the beaches of the region are packed with tourists, particularly during European holidays. The infrastructure needed to attend to the needs of tourism, i.e. shopping centres, hotels, airports, roads, dive boats, resort construction, all increase the environmental stressors on the coral reefs, but perhaps the greatest single threat from tourism is sheer ignorance. Divers, many of them unfamiliar with coral, frequently kick up sand, step on coral, or actually break off pieces of living coral as souvenirs. Dive clubs, which send divers into the reef without instructions or guidance, bear much of the blame for such actions, but even appropriate diver behaviour is linked to reef degradation at high levels of activity. It has been estimated that sites hosting more than 6,000 dives per year degrade rapidly; meanwhile, many sites around Sharm El-Sheikh and Dahab far exceed that threshold. Coral photographers, eager to get closest to the reef and distracted by their equipment, inflict over two-thirds of the damage, despite accounting for less than one-fourth of the dives.

3.1.2. Ship-based Activities

Between 1985 and 1991, an average of 1,600 vessels handling 13 to 20 million tons of cargo each year, including oil, minerals and chemicals, entered the Gulf of Aqaba through the Strait of Tiran. The lack of a local capacity to contain and control any significant accidental spills of oil is a major concern. Other environmental issues relate to marine pollution resulting from frequent small spills of oil and other contaminants. In addition, waters are polluted by garbage and animal carcasses thrown overboard by ferries and ships. Reefs are also destroyed by ships that accidentally miss the navigational waterway through the Strait of Tiran.

However, on a day-to-day basis, small, recurrent leaks from cargo and pleasure ships, land-to-sea transfers, and the discharge of oily ballast water produce more pollution and do more environmental damage overall than one-time events like a large spill. Indeed, 97% of all oil spills into the sea are in amounts smaller than 4,000 liters, and the catastrophic spills that attract the most press attention, like the Torrey Canyon or Exxon Valdez, amount to less than
25% of all the oil spilled annually. In the Gulf of Aqaba, such recurrent spills around the ports are already associated with the degraded health of local reef ecosystems.

3.1.3. Wastewater Management Practices
All urban areas are connected to biological oxidation sewage treatment systems. However, the population of Dahab and Nuweiba are not fully serviced due to insufficient infrastructure or lack of maintenance. This problem may affect up to 60% of the resident population. The remainder of the sewage is poorly treated before being released into the desert. Environmental concerns relate to possible health impacts of seepage from septic systems, pollution of marine water and degradation of coral formations. Sewage treatment facilities in the Middle East region are poor in general, often amounting to little more than open settling pools. The impact of sewage on coral reefs can be unpredictable, but devastating in some circumstances. Sewage creates localized areas of high nitrogen, which leads to algal blooms and deoxygenated "dead zones." In addition, sewage sediment settles on corals, particularly in regions without strong currents, choking the coral to death.

3.1.4. Solid Waste Management Practices
The cities in South Sinai, the port of Nuweiba, and the tourism resorts currently generate about 50 tons of solid waste per day. This has increased to 120 tons per day in 2002, and is expected to further increase to 220 tons in 2017. The municipal dumps are located unfenced and open to desert areas near the coastal desert road. Environmental concerns relate to the effectiveness of both the collection and disposal systems, which have resulted in the presence of unsightly refuse in urban and tourist development areas and throughout the desert adjacent to the town dump where open burning of rubbish also results in air pollution.

3.1.5. Ferry Traffic
Oil transport into Nuweiba is minimal. A current problem is that of shipboard waste from the Gulf of Aqaba ferry between Nuweiba and Aqaba. Much of this waste is non-biodegradable and is carried ashore by currents, adding to the problems on the coral reef and Sinai coastline. In addition, similar problems arise from land-originated solid waste from the three bordering countries.

3.1.6. Marine Aquaculture
Spurred by the demand for fresh fish from the expanding tourism industry of Eilat, the rapid development of marine aquaculture in the Eilat region has already resulted in severe pollution of the marine waters surrounding the clusters of fish cages. The lack of regulation of this activity by the Israeli Government is raising concern of further eutrophication of marine waters in the Taba Area.

3.1.7. Cruise-Boating
A visible marine pollution problem from maritime activities is the condition of the waters of the small harbor at Sharm El-Maya, in Sharm El-Sheikh. There is an accumulation of oil and sludge from the fleet of diving boats and other vessels that occupy the harbor. Further, there is no effective waste collection system in the harbor. On-board sewage and solid waste are discharged indiscriminately into the harbor waters, with obvious and detrimental impacts on the nearby hotel beaches. The potential for increasing the number of boats using the harbor poses a major localized environmental threat.
3.1.8. Floods

Desert sheet floods sporadically supply large amounts of rainwater. Such floods have occurred in the 1950s and in 1979 and 1980. In 1975, in the airport area of Sharm El-Sheikh, a rainfall of 44.5 mm was observed. On October 20th 1979, 75 mm of rain was observed at Sharm El-Sheikh, which corresponds to the average rainfall of 7 years in this area. Another catastrophic rain was observed on the 25th to 27th of December 1980, when 20.5 mm of rain was observed at Sharm El-Sheikh. This demonstrates the force of the desert sheet floods and also the patchy distribution of rain and the difficulties in estimating the influence of rainfall on such systems.

3.1.9. Southern winds

The common storms on the Gulf of Aqaba which are accompanied by winds of up to 45 to 80 knots provide considerable bursts of energy to water currents. Because some of the high winds are southerly, especially in winter, normal long shore current's flow tends to be temporarily reversed. The southern part of the gulf is the area most affected by strong southerly winds. Oceanic currents in the Indian Ocean change the level of the Red Sea and the gulf's seasonally. The effects in both gulfs are sea levels that are about 30 cm higher in winter.

3.2 Gulf of Suez

3.2.1. Tourism

The negative impacts of coastal tourism are evident in Suez Canal’s lakes and Ain Sukhna. These impacts include physical destruction of coastal habitats by construction works, dredging, and pollution from wastewater discharge from coastal resorts. The lack of proper land-use planning, including effective zoning and environmental review procedures in the coastal zone, particularly with regards to urban development and tourism expansion, is a growing problem in many parts of the region. Development often proceeds without the benefit of adequate planning or evaluation of potential environmental impacts. In some cases local authorities allow construction activities that are inconsistent with land use to proceed.

3.2.2. Ship-based Activities

One of the main sources of marine pollution in Suez Canal and Gulf of Suez is from ship-based sources. Transport of oil continues to play a critical role in marine pollution in the northern Gulf of Suez and Suez Canal. This transport traffic results in chronic marine pollution from discharges of oily ballast water and tank washings by vessels, operational spills from vessels loading or unloading at port (e.g. SUMED Pipeline Company Terminals), accidental spills from foundered vessels, and leaks from vessels in transit in Suez Bay. Other forms of ship-generated waste include oily sludge, bilge water, garbage and marine debris.

The Suez Harbour has always been an important Egyptian gate on the Red Sea since historical times. The growing activity of this harbour has led to an increasing rate of urbanization in the whole region. Taking advantage of the site location, several industries have been established all of them along the western coastal stretch of the Suez Bay down to El-Adabiya in the south. The growing industrial activities coupled with the fact that Suez represents the southern entrance of the Suez Canal have resulted in the transformation of the whole Suez Bay into a large harbour. More than 100 ships and tankers are waiting daily to cross the canal to the Mediterranean.
3.2.3. Wastewater Management

The first elements of a municipal wastewater collection and disposal system for Suez were installed during the mid 1920s. The system was expanded and modified during subsequent years, providing service to Port Tewfik area and to about 70 percent of the urbanized area of Suez at the time hostilities broke out in 1967. During that conflict, a considerable amount of damage was done to the system. Additionally, the city was evacuated and not reoccupied until 1974. During this period further deterioration occurred through disuse and lack of maintenance. Since 1974 and concurrent with general reconstruction efforts, work has proceeded to rehabilitate and to expand the existing sewerage system.

Until August 1995, the treatment plant was primitive and of limited efficiency. It included primary treatment ponds of 5 acres. The wastewater was then discharged into the bay through El-Kabanon Drain, an open drain, 6 km south of Suez. The sewerage system was constructed to serve 98% of the domestic and commercial wastewater, while 2% were discharged directly to the sea. In 1999, the discharge amounted to 75,000 m$^3$/day in winter, increasing to 85,000 m$^3$/day in summer.

A new wastewater treatment plant has been constructed, and is fully operational. It provides treatment capable of meeting the legal effluent standard for BOD (Biological Oxygen Demand) and TSS (Total Suspended Solids). The planned system of treatment includes 4 aerated oxidation ponds and 2 basins for mechanical separation of settled solids. The precipitated sludge is dredged every 6 –12 months (depending on the amount of solid material), transported to drying lagoons and then stockpiled for possible use for agriculture purposes. The plant is designed to treat 260,000 m$^3$/day.

However, the discharge of municipal wastewater at Lake Timsah and Suez Bay continues to present considerable management problems, despite the significant progress made over the last decade through investments to control pollution from this source. In the region, especially on Lake Timsah and south of Suez, the discharge of domestic sewage contributes, through nutrient loading and high biological oxygen demand, to the eutrophication of coastal waters around selected population centers, major ports and tourist facilities. The prevailing wind in Suez Bay is north-northwest causing seawater extension toward the offshore. Occasional easterly winds during winter confine the wastewaters near to the west coast.

3.2.4. Industrial Activities

The development of Suez is seen as centering on a mix of labor and capital-intensive industries, developed on the existing base of petroleum and petrochemical plants. Industries in Suez City that are functional at present include a fiberglass boat building plant, machine shop and assembly plant, merchant steel mill, ship scrapping yard, general engineering foundry, ceramic tiles plant, and denim plant. Industrial effluents, in the form of thermal pollution from power and desalinization plants, hypersaline brine water from desalinization plants of Ain Sukhna hotels, particulate matter and mineral dust from fertilizer and cement factories, and chemicals and organic wastes from food processing factories at Suez City, contribute to the land-based sources of pollution affecting coastal waters in the Gulf of Suez and neighbouring water bodies.

From the fertilizer and chemical industry, El-Nasr Company produces 1000 ton/day of ammonium nitrate, 500 ton/day of calcium nitrate and 50 ton/day of ammonium sulfate, besides, aqua-ammonia, sulfuric acid and nitric acid as byproducts. The company is located 2 km inland at about 8 km southwest of Suez City. The factory uses freshwater for cooling and the effluent discharge amounts to 60x10$^3$ m$^3$/day of low saline water (2.5%). As expected, this
water is loaded with ammonia, phosphate and nitrate in addition to certain metals e.g. Cu, Zn and Pb (Copper, Zinc and Lead, respectively). As for the cement industry, Suez Cement Factory lies 40 km south of Suez City. The manufacture of cement is a high temperature process, converting more than 30 raw materials to a fine gray cement powder. The process is energy consuming and results in atmospheric discharge of several pollutants. It was estimated that more than 10 g Pb and 600 mg Cd per ton of cement produced is released into the atmosphere. This indicates how huge the amounts of trace elements that could be added to the atmosphere through cement production. The cement factory lies on the coastal strip of the Gulf of Suez (5 km inland). Its location and the prevailing northwest winds heighten the amount of heavy metals and dust contributed by the factory to the marine ecosystem.

3.2.5. Dredging and Filling Operations

Dredging operations of Suez Canal, and dredging and filling operations associated with urban expansion, industrial development and tourism along the coast of canal lakes and Gulf of Suez are a significant source of environmental degradation in the region. Sedimentation from these operations suffocates the surrounding benthic communities and has an adverse effect on other ecosystems to which currents transport the suspended sediment. The net results are the irreversible loss of the most productive coastal ecosystems – sea grass beds and dependent marine communities.

3.2.6. Offshore and inshore oil production

Extensive oil production operations are taking place in the Gulf of Suez, both inshore and offshore. The spills from oilrigs and ships have severely affected the inter-tidal zone in the central and southern parts of the Gulf of Suez. Many rocky shores are blanketed with oil pavements and oil is found buried beneath a thin veneer of wind blown sand in some beach areas. Not only are the direct effects of spills of importance, but also, of much concern are the drilling operations themselves. The discharge of drill mud and rock cuttings during operations results in high turbidity of water probably extending for a few kilometers in depth. The sediment loading from drilling operations has killed hermatypic corals.

Beside the super tanker traffic to and from oil terminals, there are two major refineries in Suez: El-Nasr Petroleum Co., and Suez Petroleum Co. They are located in the Zeitia area about 3 – 5 km south of Suez City. Atmospheric pollution is mainly caused by sulfur oxides, hydrocarbons, nitrogen oxides, and carbon monoxide, which are released during burning gases. The refineries in Suez have old burners and the combustion of released gases is not complete, therefore causing a high emission factor for gases. Emission of elements such as As, Cd, Co, V, Ni and Cu (Arsenic, Cadmium, Cobalt, Vanadium, Nickel, and Copper) are also included.

3.2.7. Power Generation

The thermal power station at Ataqa (8 km South of Suez) is one of the largest in Egypt designed to generate 900 megawatt/hour of electric power. Cooling water is taken from the Suez Bay via an open canal extending over a half kilometer into the sea. A water temperature rise of about 1°C due to the thermal effect of the effluent is recorded in the near shore waters. The cooling effluent is about 200 m³/hour, while the sewage discharge is 100 m³/day.

3.2.8. Fishing

Improper resource management, in conjunction with a lack of low enforcement, is a barrier to sustainable development of the marine resources in the Gulf of Suez. Ultimately, this poses a serious threat to its biological diversity and productivity, and puts at risk the livelihood
of people engaged in potentially sustainable activities, such as fisheries and aquaculture. The status of fisheries is unknown because of a lack of stock assessment and incomplete and unreliable fisheries statistics. Interviews of fishermen reported declines in catches and average size of fish landed, which indicates over-fishing and stock depletion. The present situation is attributed to destructive fishing practices, possible exploitation beyond maximum sustainable yield, the absence of fisheries management plans, and a lack of surveillance and enforcement of existing regulations.

4. Sources and Levels of Pollution

Sources of pollution from land and marine-based activities, and the levels of pollution recorded by way of monitoring and investigation have been identified for Sharm El-Sheikh. Data recorded for Sharm El-Sheikh is the only available data for the sources and levels of pollution in the Gulf of Aqaba as a whole. Similarly, data recorded from Suez City, Suez Bay, and Ain Sukhna is used as representative data of the conditions in the Gulf of Suez. The sources of pollution can be categorized into: sewage, persistent organic solids, radioactive material, heavy metals, oils (hydrocarbons), nutrients, sediment mobilization, and litter. For each source of pollution listed, the level of contamination or degradation is presented for the Gulf of Aqaba and the Gulf of Suez, respectively.

4.1. Sewage (GofA)

Sewage is the liquid waste, which consists primarily of used water, with 0.1% of solids made up of inorganic and organic matters. Domestic sewage consists of discharges of dirty water from bathrooms, lavatories, and kitchens. This liquid is a mixture of minerals, organic matters, detergents, and solid particles in addition to microorganisms (bacteria, viruses, and protozoa). The faecal bacteria are considered in general as a bio-indicator for domestic water pollution. The faecal bacteria are known to be excreted in high numbers in all faeces, and some of these bacteria have been shown to be present exclusively in faecal material. Therefore, the presence of faecal bacteria in water or sediments can be taken as an indicator for the presence of certain faecal material.

The sewage problem in Sharm El-Sheikh area is very limited or eventually controlled because of the Law 4/1994 where any direct discharge of untreated or treated sewage to the marine environment is prohibited. All hotels have to comply with these requirements and have acquired a sewage treatment system, or have been connected to the city sewer system. The treatment should be of tertiary or at least secondary treatment, where the remaining sludge is trucked away to the city municipal dumping area and the liquid effluents is treated to meet specified limits before being discharged to wells.

In 1999 a bacteriological assessment for the water quality of Sharm El-Maya bay (in Sharm El-Sheikh) accomplished by Suez Canal University revealed the presence of faecal bacteria in water samples collected from different sites in the bay. The bacterial counts for total coliforms recorded in Sharm El-Maya and the acceptable counts in the guidelines were 9–26 and 100 (cfu/100ml), respectively. The presence of faecal bacteria was attributed to the previous use of Sharm El-Maya as a berthing site for more than 200 motorized boats. These boats evacuate their waste in the water directly (none of the boats had holding tanks for their waste, and there was an absence
of onshore waste receiving facilities). After 1999 the count of total coliform decreased as a result of moving the boats to the new jetty at Sharm El-Mena. A new port established in 1999 at El-Sharm Bay (TRAVCO Port) forced, by law, 300 diving boats anchoring there to carry septic tanks for wastewater, which are later pumped to the city sewer system by special receptors in the jetties. Only 80% of the boats, however, apply this system, while the remainder still discharge their wastewater directly into the Gulf of Aqaba without treatment, causing serious pollution and damage to the habitats of the bay and the adjacent reef.

The marine environment of the Suez bay is subjected to mixed sources of pollution (industrial, agricultural and domestic sewage) through the direct discharge of El-Kabanon drain, which is considered the main industrial and sanitary drain. Approximately 120,000 m$^3$/daily of sewage is dumped through El-Kabanon drain into the Suez Bay. The sewage discharged into the Suez Bay contains 93.76 ton/year of ammonia, 0.305 ton/year of nitrite, 0.397 ton/year of nitrate, 52.93 ton/year of inorganic phosphate, 0.409 ton/year of copper, 3.65 ton/year of zinc, and 0.120 ton/year of lead.

4.2. Persistent Organic Pollutants (POPs)

Law 4/1994 regulates the application of pesticides, herbicides and fertilizers in any sensitive environment. These regulations enforce the insulation of plantation areas with plastic sheets to prevent any leakage of the irrigation water or fertilizers to the waters. The law also prevents any direct or indirect discharge of PCBs, DDT, DDD, DDE and Aldrin from drains or irrigation canals. In an attempt to detect any contamination due to persistent organic pollutants in the Sharm El-Sheikh area, water samples were analyzed for Hexachloro Cyclo Hexane isomers (HCH) and the obtained results were beyond the detection limits.

In Egypt, organochlorine pesticides were extensively used to control various agricultural pests until their use was curtailed in the early 1970s. Heavy reliance on such insidious compounds has had its environmental drawbacks. Numerous reports have illustrated the accumulation of organochlorine residues in different matrices, including human milk and different brands of commercial cow milk in Ismailia. Also residues were detected in fish, crab and sediments from Lake Timsah. Organochlorine pesticides exert their detrimental effect on living organisms through their chronic toxicity, sub lethal exposure coupled with their exceptionally long persistence. Residues of organochlorine insecticides were extracted from several water bodies, including irrigation canal, main drain, collector drains, brackish water of the Bitter Lakes and tap water around Ismailia. Hexachloro Cyclo Hexane (HCH) isomers were the most prevalent compounds detected. The highest residue concentration was detected in collector drains. Results also showed high concentration of Dieldrin in drainage water, such high concentrations might be due to metabolic conversion of Aldrin. The residues of Aldrin may indicate fresh applications. In addition, residues of DDT along with its degradation metabolites products, DDD and DDE, indicate degradation of previously applied DDT along with fresh application of DDT.

4.3 Radioactive Substances

No data on any radioactivity study in Sharm El-Sheikh area was available. However, phosphate shipping from Aqaba port in the north of the Gulf of Aqaba produces dust that affects the seawater and marine life. This, in turn, increases the productivity of the water, enhances algal growth and increases water turbidity; both factors have direct impact on coral growth. Phosphate ore include a relatively high
percentage of radioactive materials, so it is essential to carry out regular sampling in the area to measure the level of radioactive isotopes.

After the Chernobyl accident in the late 1980s, a pilot survey of radioactivity along the Suez Canal was accomplished. The results fall within the normal ranges and the actual report was not published.

4.4. Heavy Metals

Heavy metals come from several sources, including leaded fuel additives, lead in bilge from boat ballast; arsenic from paint pigment, pesticide, and wood preservatives; zinc used to deter metal corrosion; copper and tin from biocidal antifouling agents; and other metals from jetty construction. Also it exists in re-suspended sediments by boat operation and dredging activities. Aquatic organisms concentrate many of these pollutants through biological activity. The sediments can also accumulate these pollutants to higher levels, and in turn act as a potential source of pollution.

During the rehabilitation of Sharm El-Maya project in 1999, the heavy metal concentrations in the bay sediments were measured. Generally, the measured metals (Copper, Cu; Zinc, Zn; Cadmium, Cd; and Lead, Pb) showed significantly higher levels (7.3, 68.9, 3.5, and 20.8 ppm) i.e., 2 to 4 times higher compared to the control site concentration (4.8, 29.4, 1.2, and 5). Although, trace metals in the bay sediment showed clearly higher levels than the control site, most of the values were found to be within the range of the comparative survey made on sediment samples collected in 1983 and 1984. The range of the metals were 13-80, 15-100, 0.1-2 and 0.8-15 mg/kg-dry weight sediment for Cu, Zn, Cd, and Pb, respectively. On the other hand the metal concentrations in Sharm El-Maya water ranged between 0.08- 0.115, 0.131-0.509, 0.143-0.169, and 0.390-0.533 mg/l for Cu, Zn, Cd, and Pb, respectively.

Research was carried out on heavy metal pollution in Suez Bay, where the bay is subjected to industrial run-off from oil refineries, fertilizer plants, and power station in addition to sewage and garbage. The heavy metal concentrations ranged from 7.2 to 147.7µg/l for Zn, 10 to 62.6µg/l for Cu, 0.7 to 12.1µg/l for Pb and 0.01 to 1.27 µg/l for Cd, respectively. Adabiya station showed the highest values because of the various pollution sources discharged (i.e., harbours, sewage, and industrial drains), while in contrast the station of Ain Sokhna showed the lowest concentrations.

In the Suez area, investigating the possibility of using seaweed as an indicator for trace metals pollution was carried out in 2003. The study investigated the trace metals concentration within sediment, water, and seaweed. In water, the annual mean concentrations were 0.272, 0.166 and 0.438 ppb for dissolved, particulate, and total Cadmium (Cd), respectively. While in sediment the Cadmium concentration was 5.670 ppm. Lead (Pb) in water showed annual mean concentrations of 1.096, 2.085, and 3.181 ppb for dissolved, particulate, and total lead, respectively; while in sediment lead concentration was 29.748 ppm. The annual mean concentration of Copper (Cu) in water was 0.972, 0.782 and 1.561 ppb for dissolved, particulate, and total copper, respectively. The total annual mean concentration of copper in sediment was 8.785 ppm with the highest value being 10.454 and the lowest being 3.506 ppm. Finally the recorded Zinc (Zn) annual mean concentrations were 20.76, 258.54, and 279.30 for dissolved, particulate, and total zinc, respectively. The mean Zinc concentration in sediment was 22.771 ppm. The study concluded that sediment is highly polluted by cadmium and in less degree by lead. Also the metal concentrations correlated with industrial activities.
4.5. Oils (Hydrocarbons)

In 1999 levels of Total Petroleum Hydrocarbons (TPH) were measured at Sharm El-Maya bay in sediments and water samples. The calculated mean of TPH in surface and deep water (close to the bottom) was 351.3 – 295.3 ppb, respectively; and 43.1 – 32.2 ppb at the control site. Generally, the TPH levels had a narrow average between the minimum and maximum-recorded concentrations. In the surface water of the bay, TPH concentrations ranged between 185.6 – 591.8 ppb. While in deep waters, the concentrations were 134.5 and 618.7 ppb. The Total Petroleum Hydrocarbon content was analyzed in surface (0 – 20 cm) and deep sediments (20 – 40 cm). The highest concentrations were found to be in the surface sediments rather than the deep sediments at all the investigated sites including the control site. The minimum levels were recorded in the surface and deep sediments of the control site (14 and 6 ppm). The highest concentration was found in the inter-tidal sediments (1263.5 ppm) while the lowest concentration was recorded in the deep sub-tidal sediments (57.1 ppm).

Ain Sukhna area received the attention of several studies, and it was concluded that the area is suffering from extensive chronic pollution inputs as it is evident in the vicinity of the SUMED pipeline company terminals, which include both floating and land-based receiving terminals.

4.6. Nutrients

The nutrient salts (nitrate, nitrite, ammonia, phosphate and silicates) were measured in the Sharm El-Sheikh area during the rehabilitation project of Sharm El-Maya in 1999. There are different sources of nutrient salts in the marine environment, which include the flushing of lavatories and sinks of safari and diving boats on reefs while anchoring; and the uncontrolled disposal of food, drinks and wastes in water which was obvious in Sharm El-Maya.

Nitrate (NO₃-N) concentration inside the bay was higher in surface water than in deep water with an overall mean of 1.101µg at/l and 0.912µg at/l. Also all sites showed a high concentration compared to the control site, both in surface and deep water (1.015µg at/l and 0.275µg at/l).

Nitrite (NO₂-N) also showed a higher concentration in surface water than in deep water. The concentration ranged between 0.086µg at/l and 0.053µg at/l, respectively. The obtained results at all the sites were higher than the results obtained at the control site; 0.016µg at/l for surface and deep water samples.

Ammonia (NH₃-N) is similar to nitrite and nitrate. The overall mean of ammonia concentration inside the bay was higher (0.830µg at/l and 0.974µg at/l) than the values recorded at the control site (0.69µg at/l and 0.73µg at/l) in the surface and deep water, respectively. Furthermore, a general trend of increasing ammonia levels in the deep water than the surface was observed at all sites.

Phosphate (PO₄-P) has higher concentrations that were recorded at all the sites and ranged between 0.270µg at/l and 0.302µg at/l in surface and deep water, respectively. Whereas the recorded values at the control site was 0.18µg at/l at both water layers.

Silicate (SiO₄-Si), the mean deep water of the bay contained higher concentration than the surface water (3.8µg at/l and 3.65µg at/l). This is in contrast to the control site where the surface water concentration was higher than the deep water values (4.1µg at/l and 2.9µg at/l).

In the Suez area, a study was carried out in 2003 to measure nutrient salts around the Suez Bay and down to Ain Sukhna area. Nitrate concentration ranged between 0.650µg at-N
The highest value of nitrate recorded was attributed to the fertilizer waste from El-Nasr fertilizer factory and sewage waste disposal from El-Kabanon drain. El-Nasr Factory produces 1500 ton/day of nitrate salt and discharges 14000m³/day of low saline wastewater. Nitrite concentration varied between 0.150 – 3.740 µg at-N/l. The nitrite concentration recorded was higher than that recorded previously in 1999 (0.00-2.90 µg at-N/l). Ammonia concentrations ranged from 0.57 -89.290 µg at-N /l with an annual mean of 9.952 µg at-N/l. Also, ammonia concentration recorded in 2003 was higher than the one recorded in 1999, which ranged from 0.14 to 19.39 µg at-N/l. Finally, the recorded values of Phosphate ranged between 0.22 – 1.64 µg at-P /l while the recorded values in 1999 was lower and ranged between 0.04 -1.21 µg at-P /l.

4.7. Sediment Mobilization

Sharm El-Sheikh area was lucky enough not to repeat the Hurghada story on land filling, dredging on the reef to create inland lagoons, and construction of concrete jetties. Therefore, the amount of sediment resulting from such activity was very limited and kept within normal values. In a study to evaluate the human impacts on coral reef at Sharm El-Sheikh area, sediment traps were installed at all the diving sites at different depths. After 6 months the sediment traps were retained back to the laboratory for examination. The obtained results indicate that the variation in the amount of sediments collected could not be attributed to the number of divers but to environmental parameters. This is obvious on the sites facing Gulf of Suez with low number of diving sites but have the highest sediment content. On the other hand, the sites inside Sharm El-Sheikh have lower sediment content (Ras Um El-Sid, El-Tower, Ras Nasrani, and Shark Bay). Sediment pollution is a concern for coral reefs on a global scale, but phosphates are a particular concern in the Gulf of Aqaba region. Sediment deposits block sunlight from reaching the corals, which require light, and clog the tiny orifices of the coral, effectively starving whole colonies to death. In the Gulf of Aqaba region, sediment deposits have become an environmental threat due to over development of ports, hotels, piers and tourist facilities along the reefs, from which the dust from construction and building materials wash into the sea.

The huge urbanization and coastal development along Bitter Lakes and the northern area of the Gulf of Suez resulted in land filling and dredging of coastal flats to construct lagoons and swimming pools at hotels, and to construct the Ain Sukhna Port. Some of these destructive activities took place before the enforcement of Law 4/1994.

4.8. Litter

Litter originates from various sources within the coastal environments such as waste from land reclamation and waste from daily diving operations. Currently in Sharm El-Sheikh the litter could only be traced on Sharm El-Mena boat harbour, in the dwelling area or the area under construction. The enforcement of Law 4/1994 dictates that any litter should be collected and disposed properly in the city disposal site. In TRAVCO Port, diving boats deliver between three to five tons/day of solid wastes, handed to transfer to city dumping sites. Although the bottom of the bay is covered intensively with solid wastes from the anchoring boats, a lot of them were washed to the shore.

In 2000, the Marine Science Department initiated a survey for beach cleaning and collecting litter and garbage from Sharm El-Mena area in front of the field station of Suez Canal University. The beach was divided into sectors of similar areas,
and every collected item was segregated within its type. The result showed that most of the litter originated from safari and diving boats. The different items collected were shredded car tires used as boat fenders, empty food and beverage cans, gas lighters, glass bottles, oil filters, and empty barrels. There was no data available regarding litter in the Gulf of Suez area.

5. Adverse Impacts and Environmental Degradation in South Sinai

The marine environment should be well protected from adverse impacts of pollution to ensure the sustainable use of its resources and good health of its users. Continuous degradation of the marine environment poses a threat to public health through the contamination of seafood, and direct contact and digestion of polluted water. Damage to the marine ecosystems adversely affects tourism and fisheries. The preservation of a high level of biological diversity is essential for the future protection of human health, as the taxonomic knowledge of the species is still far from complete. It is thus essential to guard against the extinction of the largest possible number of species, among which are some that may in the future provide us with food and medicine or be used in the biological control of pests and pathogens.

The marine environment of the Gulf of Aqaba and the Gulf of Suez rests on the interaction between key ecosystems that form a continuum between the land and the sea. A coastal zone that is the traditional site of human settlement and economic activities dominates the land. These ecosystems are under variable pressure in the region, with greatest stress adjacent to urban and industrial areas, near port facilities, and in the vicinity of coastal tourism areas. Most of the Gulf of Suez could be fairly considered the area at most risk of oil pollution in the Red Sea. The effect of oils (hydrocarbons) could propagate southwards to the Hurghada area, and even further south, through dispersal with the prevailing coastal currents especially during the summer. A discussion on the negative impacts of the activities in the Gulf of Aqaba and the Gulf of Suez area presented in this section aims at focusing on the impacts insofar as they relate to South Sinai.

The total area of the south Sinai Governorate is about 30,000 km²; only about 11,492 km² from the total area is populated. The population density in 1986 was about 2.52 person/km, which is considered a relatively low density. South Sinai Governorate could be considered a population-attraction governorate especially with the great expansion of tourism activities, which provide a good number of jobs and a good chance for investment. South Sinai Governorate is one of smallest populated governorates in Egypt. In 1982, it had 29.4% urban population and 70.6% rural population, while in 1995 it was 40.2% urban population and 59.8% rural population.

5.1. Escalating Large-Scale Tourism increasing

Large-scale tourism was expected to quadruple by the year 2000, and is on an upward trend. Sharm El-Sheikh being only four hours from most European cities is now a popular destination offering desert, beach, and vacations. Impacts of tourism developments can already be seen off Hurghada, where sedimentation from coastal development has seriously damaged reefs. The use of imported fine sand for hotel beaches off Dahab threatens these
reefs. Eutrophication problems related to nutrient rich sewage water from hotel gardens, as well as desalinization effluents pumped onto reefs from hotels in Quseir and Dahab threaten reef health. Hotels, resort areas, and other development projects, in the area, if unregulated along the shoreline may add to the decline of the coast by dumping raw sewage into the sea, adding to turbidity from runoff, promoting physical removal of coral for souvenirs, and destruction of reefs and vegetation from dredging and filling operations.

5.2. Declining Reef Fisheries

The coral reef environment supports a rich and diverse assemblage of fish. Reef fish are often spectacularly colored and may be encountered individually (e.g. groupers, parrot fish, morays), in pairs (e.g. butterfly fish, anemone fish), and in shoals (damsel fish, sergeant major, snappers). Each part of the reef is inhabited by a characteristic assemblage of fish. They show a wide variation in feeding behaviours: surgeon fish and parrot fish are herbivores; mullet are detritivores; damsel fish and fusiliers are planktivores; chaetodontids, puffers and labrids include omnivores and specialized carnivores; moray, scorpaenids and stonefish are benthic carnivores; groupers, snappers, sweetlips, and squirrelfish are mid-water predators and often may fall prey to jacks, tuna and sharks. Large open water planktivore, which may be seen along the reef are manta rays and, rarely, whale sharks. At the other end of the size spectrum, garden eel are demersal planktivores. Other fish species, which occur in burrows, such as goby, live in association with burrowing shrimp in parts of the reef system where sediment accumulates.

Fishing pressure is increasing as the emphasis shifts from sustainable to extractive fishing practices. Lobsters are presently over fished around Sinai. Sharks in the area are reportedly declining for unknown reasons, possibly because of tourism-related activities such as boating. The status of fisheries is unknown especially along Suez Canal because of a lack of stock assessments and incomplete and unreliable fishery statistics. Interviews with fishermen reported declines in catches and average size of fish landed, which indicate over fishing and stock depletion. The present situation is attributed to destructive fishing practices and possible exploitation beyond maximum sustainable yield. The situation is amplified due to the absence of fisheries management plans, and lack of surveillance and enforcement of existing regulations.

5.3. Threatened Seabirds

Many species of birds utilize the coastal Red Sea habitats, where the islands provide suitable nesting sites for sea birds such as terns and gulls. Mangroves provide sites for herons, cormorants, and ospreys. The beaches and littoral are a haven for a variety of passerines, birds of prey, waders, and shore birds. The Red Sea is an important bird migration route for European birds going to and from their wintering grounds in Africa. The islands, mud flats, and mangroves constitute important resting habitats for various migrant species. Three developments in the Red Sea countries affect seabirds; which are the oil industry, tourism and fisheries. The major threats to seabird population are direct exploitation by humans, competition with fisheries, pollution, poisoning, habitat disturbance and destruction.

5.4. Disturbance to Marine Turtles

Turtles are very common in the region. The green turtle appears to be most common, with nesting activity from around the southern tip of Sinai and Tiran Island. Like all chelonians, sea turtles not only are air breathers but depend on dry land, for they nest on sandy
beaches above the highest tides. Their eggs are normally laid at night in clutches of 100 or more and then buried in the sand and abandoned to incubate with the heat of the sun. Within 6 to 10 weeks the eggs hatch, and the baby turtles dig their way up to the surface and scramble to the sea. Both eggs and hatchlings are especially liable to predation. Sub adults and adults are common in shallow waters over reefs, in marine pastures of sea grass and sea weeds, or even in protected bays. They feed on sea grass, sponges, soft corals and other sessile soft-bodied invertebrates that grow in nooks and crannies of coral reefs. Turtles are vulnerable to coastal pollution (especially oil pollution), litter, plastic bags, fishing nets and recreation which occupies the beaches and leave no space for aggregations of turtles through the spawning season.

5.5. Miscellaneous Disturbances
Thermal and biocide effluents from industrial sites using sea water for cooling purposes, as well as salt brines with their highly saline wastes from desalinization plants, constitute potentially damaging forms of marine pollution. Very little is known of the amounts and effects of the insecticides and chemical fertilizers that run off into the sea. In the Gulf of Aqaba, pollution from port facilities in Eilat, Israel and Aqaba, Jordan threaten water quality.

5.6. Destruction of Coral Reef
The extensive coral reef formations along the Gulf of Aqaba coast present the greatest potential exposure to serious environmental damage. Although current degradation of the reef is limited to discrete areas and effective measures have been initiated to protect the reef, an increase in tourist visitation on the scale anticipated will put considerable pressure on the remaining reef and on the monitoring activity. The seriousness of the potential risks arises from the global significance of the Aqaba reef formation and the heavy reliance on promoting the reef’s attractions in marketing the area for tourism. In those areas where damage has occurred, it has taken the form of direct physical contact from bathers, snorkellers, divers and boat anchorage. Damage has also occurred from wind-blown plastic debris, which covers the coral. In a few areas, construction activities immediately adjacent to the shoreline have resulted in construction debris falling on the reef. Increased tourist traffic, unmonitored diving activity outside the core protected areas, increased coastal construction, failure to address the plastic waste problem, and potential oil spills, all pose a threat to this important natural resource.

5.6.1. Effect of Sedimentation
Sedimentation is one of the major factors affecting the distribution of corals. The sediment particles reduce light available for photosynthesis. Excess sedimentation can affect the structure and function of the coral reef ecosystem both physically and biologically. Heavy sedimentation usually associated with lower coral species, less live corals, lower rates of growth, greater abundance of branching forms, reduction in coral recruitment due to reduction in the total number of larval settlement, decreasing calcification rates, and slower rate of accretion. Sewage delays or prevents re-colonization of corals on dredging surfaces by stimulating growth of algae, which compete with corals for space. Mangrove forests usually have turbid water most of the time because of the water turbulence over the muddy bottom, which characterizes those areas.

5.6.2. Effect of High Temperature
Marine thermal conditions have been recognized to have strong influence on coral reef development; growth, and distribution. Coral bleaching events, which occurred throughout the Caribbean and elsewhere in 1987, were generally attributed to elevation of water temperature. Desalination plants established in each hotel around the beaches of Sharm El-Sheikh discharge their brine wastes directly to the beaches, with its high nutrients and relatively high temperature, which bleach corals and enhance the growth of filamentous algae.

5.6.3. Effect of Oil Pollution

Oil pollution is a human-induced factor, which puts another stress on the corals’ community growth, and affect coral distribution. Crude oil with its poisonous compounds, which dissolve in seawater, can affect coral distribution and growth. Surface oil film can hinder the oxygen exchange between air-water surfaces and reduce the oxygen supply, besides reducing light, which affects the photosynthetic process. Oil-depressed growth rates of corals in Eilat were observed. Damage of the reproductive system of corals and almost complete lack of re-colonization of hermatypic corals in reef areas chronically polluted by oil in the Red Sea were also observed.

5.6.4. Effect of Human Disturbance

Human activities disturb coral living communities by those bathing, swimming, snorkeling and diving. Collecting snails, mussels, sea stars and rare specimens by tourists and those who sell them to tourists, affect the living ecosystems in the area. Tourism-oriented structures and facilities below low water mark, such as permanent vessels and aircraft moorings, underwater observatories and floating, bottom-support and submerged structures are intrusive to the environment. Offshore Tourism Development (OTD) is becoming important and significantly extends the opportunities for reef users, such as those diving, snorkeling, reef walking, photographing and fishing. Coral damage due to anchoring or tourist related activities, such as spearfishing, coral gathering or diver fanning is extensive.

5.7. Degradation of Coastal Land-Interface

The condition of the immediate coastline in currently developed areas illustrates the potential for significant environmental degradation posed by increased tourist development. Where hotels are sited close to the shore, there has necessarily been an alteration of the beach by addition of sand to make the beach more attractive for tourists. In some areas, construction debris has been allowed to degrade the shoreline, and in much of the area outside of the developed tourists areas, the coastline is cluttered with waste materials, particularly plastic. All of these problem stem from unregulated and insensitive activity on the part of tourists and developers, all of which can be prevented with improved environmental sensitivity and enhanced monitoring by regulatory agencies. Without such actions, the anticipated increase in tourist activity will increase the scale and extent of degradation along the shoreline.

5.8. Destruction of Desert Ecosystem

The desert ecosystem is extremely sensitive and less resilient than that of the sea. In the prevailing arid conditions and the somewhat minimal vegetation and animal diversity that characterize the southern South Sinai desert, anthropogenic impacts are generally adverse, highly visible and long-lasting. Because access to the desert has been limited to date, so far the visible adverse impacts are minimal (except for solid waste). Increased tourism, however, will bring increased interest in desert tours and safaris. Consequently, efforts to control and mitigate the impacts are becoming more important.
5.9. Environmental Degradation Affecting Socio-Economic Conditions

With internationally recognized coral reefs, clear warm coastal waters, outstanding desert landscapes, sites of cultural and religious importance and near permanent sunshine, it is clear that the wealth of southern Sinai lies in its natural resources. Those resources, coupled with their proximity to European tourism markets, have stimulated the rapid growth of tourism development that the region is currently experiencing.

Expansion of the local tourism economy in 1995–1996 is reflected in the number of rooms and beds available in the area for different sites. It is clear, that Sharm El-Sheikh area has the largest activities in tourism, and therefore required more attention to keep this area a center for tourism economy. The number of hotels increased from 37 in 1996 to 126 in 2003, number of rooms increased from 3,899 in 1996 to 27,000 in 2003, and number of beds increased from 8,117 in 1996 to 54,000 in 2003.

Bedouin population in southern Sinai is broken down into 8 tribes. The protected areas of Nabq and Abu Galum are inhabited by two of these tribes, the El Mezeina, one of the largest and most powerful tribes inhabits the southern gulf from Nuweiba to Sharm El-Sheikh, and the El Tarabin who live in the area from Nuweiba to Taba. The total Bedouin population in these areas is approximately 3000 individuals. Numbers of Bedouin now reach about 20,000 individuals. Bedouins have traditionally occupied the Sinai Peninsula. Women graze their sheep and goat, while the men fish. These activities are most likely to damage habitats, or reduce their biodiversity. Protected areas are now regulated by EEAA staff in cooperation with concerned Bedouins. Bedouin culture has been founded on strict tribal laws and traditions. Nature is respected, water is consumed sparingly, small water reservoirs are constructed on hillsides to assist wildlife, and thus, damage to reef areas is limited.

5.10. Physical Alteration and Destruction of Habitat

The important coastal and marine environments and resources of the Suez Canal and Gulf of Suez are subject to a series of individual and cumulative threats, which have significant short and long-term consequences for sustainable development of the region. The threats include habitat destruction, over–exploitation of living marine resources, environmental degradation from sewage discharge, significant risks from marine transportation, pollution from industrial activities, diverse environmental impacts from urban and tourism developments, and a series of emerging environmental issues associated with new types of economic developments.

5.11. Increased Coastal Construction

Coastline alteration such as dredging, e.g. Lake Timsah, and filling operations of shallow areas and the excavations of artificial lagoons, and the construction of huge marine structures, e.g. Ain Sukhna Port, are some of the environmental problems identified. They are causing massive destruction of marine life and key habitats in several locations along the Suez Canal and Gulf of Suez. Currently, the original coastline has been completely altered by dredging and filling operations. In addition to the direct destruction of marine life by dredging, filling, and other coastal construction and modification operations, suspended fine sediments resulting from these activities inflict widespread damage on marine biotic communities.
5.12. Loss of Sea Grass Habitats

Sea grass is usually found in shallow waters close to the shoreline. Their location renders sea grass very susceptible to activities related to unplanned and unmanaged urban, industrial, tourism, and fishing activities. Sea grass is destroyed directly by dredging, land filling, or discharge of sewage. Productivity is degraded by changes in water flow caused by coastal constructions, excessive sediment in the water reducing available light, and the impacts of increased nutrients in the water from sewage disposal. These problems are compounded by a lack of environmental assessment procedures for developments, lack of awareness about the importance of sea grass, and lack of information on their distribution. Although legally protected from trawling, sea grass beds are destroyed by illegal trawling (which is difficult to prohibit). Impacts on sea grass beds affect the fauna, which depend upon them, as well as commercial fish and crustaceans.

6. Mitigating Measures

Several environmental initiatives have been identified for investment or technical assistance for the Gulf of Aqaba and the Gulf of Suez. Some of the actions undertaken to mitigate the negative impacts in the Gulf of Aqaba include marine pollution prevention, flood and earthquake protection, water and wastewater management, solid waste management, protected areas management, and public awareness and environmental education. Similarly, in the Gulf of Suez, similar initiatives to alleviate some of the adverse effects include reducing physical alteration and destruction of habitats, minimizing discharge of sewage and nutrients, and minimizing the release of organic and industrial pollutants.

6.1 Gulf of Aqaba

6.1.1. Marine Pollution Prevention

Marine pollution prevention consists of establishing the Ras Mohamed and Nuweiba oil spills emergency centers; constructing sanitation facilities in Nuweiba and other ports; and designing and implementing a marine water quality monitoring program to assess and establish measures to maintain water quality. The monitoring program will provide baseline data and updated indices of ambient conditions including, quantity, distribution, fluctuation, and movement of natural components of the marine water body as well as the occurrence and levels of pollutants.

6.1.2. Flood and Earthquake Protection

Flood and earthquake protection plan for the whole coast and monitoring implementation of earthquake building codes are put in place for design.

6.1.3. Water and Wastewater Management

Water and wastewater management will necessitate monitoring of brine effluent from desalination plants, and effluent of treatment plants within the context of the marine water quality program; fully connecting the Taba, Nuweiba, Dahab, and Sharm El Sheikh municipalities and all hotel complexes to a sewage collection and treatment system; developing and implementing an action plan for wastewater reuse; and reducing loses in the water distribution systems of Nuweiba and Dahab.
6.1.4. Solid Waste Management

Solid waste management focuses on implementing solid waste collection, recycling and disposal systems from the Aqaba coast, and implementing a solid waste collection on the Nuweiba-Aqaba ferries.

6.1.5. Protected Areas Management

Protected areas management will build on the ongoing work of EEAA’s Department of Nature Protection. It will consist in completing equipment and staff training for Nabq and Abu Galum Managed Resources Protected Areas; reinforcing Bedouin program activities; increasing protection of coral reefs in the core protected areas; designing and enforcing appropriate regulations and licensing systems outside core protected areas; establishing and enforcing a licensing system for tourism activities in protected desert ecosystems, especially in desert areas in the vicinity of coastal developments; implementing a research program on the carrying capacity of the coral reefs; designing and implementing a visitor/tourism operator environmental awareness program; upgrading GIS capacity network; providing a communication system; and studying bird migration.

6.1.6. Public Awareness and Environmental Education

Public awareness and environmental education will consist of designing and implementing an education program aimed at increasing public support and participation in the protection and management of the environment of the Gulf of Aqaba. The program will encourage the participation of members of the general public, specific socio-economic and interest groups (such as the private sector and tourists), and NGOs in both the development and implementation of the action plan, including identification of problems, the development of solutions, and subsequent monitoring of environmental concerns.

6.2 Gulf of Suez

Priorities for pollution problems were established on the basis of the nature and severity of the problem, the type of contaminants, the physical alteration and destruction of habitats, the sources of degradation, and the nature and extent of the affected area. The severity of the problem was assessed on the basis of food security, public health, coastal and marine resources, and ecosystem health and the economic and social benefits and uses. On the basis of the issues considered in the previous sections, it is evident that the main land-based sources of pollution originate from continuous coastal development projects, sewage treatment facilities, industrial facilities, and power and desalination plants. Accordingly, following are the priority issues that have been identified.

6.2.1. Reducing Physical Alteration and Destruction of Habitats

Analysis of the above priority issues on the basis of type of pollutant, severity of impact, area affected and economic considerations has revealed that physical alteration and destruction of marine habitats should be considered the first priority issue along Suez Canal and Gulf of Suez. Tourism developments on the coast of the Bitter Lakes and Ain Sukhna have required significant dredging and filling operations to develop huge marine structures with artificial lagoons and sandy beaches. The dredging and filling operations have caused considerable damage to marine life and key habitats. In addition, the suspended solids generated during these operations cause significant damage to the benthic communities, as the
suspended solids can be carried by the prevailing water current over long distances and thus cause widespread damage to marine life.

6.2.2. Minimizing Discharge of Sewage and Nutrients

Sewage was considered to be second priority issue in study sector of Suez Canal and Gulf of Suez. Because of rapid population growth and urbanization and the lack of adequate treatment and disposal facilities for municipal waste, untreated and partially treated domestic and municipal wastes are dumped in the coastal areas and into the sea in and around the main cities of Ismailia, and Suez. Handling (collection, treatment and disposal) of these wastes in an environmentally sound manner should be considered one of the country's top priorities. The widespread impact of the sediments with high content of organic matter has been observed in Lake Timsah, and the west coast of the Bitter Lakes, where such sediments have spread to extensive benthic communities, forming a thick anoxic veneer of fine sediments on the surface of sea grass and shallow water communities resulting in their death.

6.2.3. Minimizing the Release of Organic and Industrial Pollutants

The issue of persistent organic pollutants is of particular importance because of the substantial use of pesticides, insecticides, and herbicides for agricultural purposes. Considerable agricultural activities have been established in the Suez Canal and Suez Bay. Fertilizer and pesticide residues are being discharged into them as a result of agriculture runoff. The high phosphate loads entering the marine environment can result in significant eutrophication. In addition, the two main fertilizer and chemical industries in Suez discharge about 3,713 m³/day of industrial waste, containing various organic pollutants into the Gulf of Suez.

7. Recommendations

Current and anticipated economic and social developments in the region are expected to result in new environmental pressures and threats to coastal and marine resources. The management of emerging issues should be addressed through the adoption of preventive actions to avoid unnecessary environmental degradation or resource depletion. This section contains some recommendations for marine pollution prevention in general for the Gulf of Aqaba and the Gulf of Suez.

7.1. Gulf of Aqaba

Environmental protection should necessarily be included in all development strategies. Training of personnel involved in activities and projects to control the degradation of marine environment from land based activities with the help of EEAA personnel.

Development of a regional programme for the monitoring of marine pollution in the coastal area of the Gulf of Aqaba.

Development of a strategy, including a program of action for the protection of the marine environment of Sharm El-Sheikh from land based activities.
Establish a system and a plan of action for collection and disposal of solid waste and sewage either from the land-based activities or marine activities, especially diving boats.

Considerable progress has been made in the region in the collection and treatment of municipal wastewater; however, investments continue to be required for extension of collection networks, expansion and upgrading of treatment facilities, and development of safe wastewater reuse in terrestrial coastal zone and disposal systems. Serious efforts are also needed to ensure proper operation and maintenance and reliable performance of existing treatment facilities.

Establish a monitoring program and action plan for Sharm El-Sheikh Port based in Sharm Bay to protect the Marine Park of Ras Mohammed from the side effects of the pollution caused by the marina.

Develop a good system to protect underground water and coastal waters from the seepage of treated sewage water from gardening in Sharm resorts and green areas.

A water-quality monitoring programme should be established, to assess current marine water quality, and measures established for maintaining and improving water quality. The monitoring programme should include monthly baseline testing at selected locations both along the coast (including bathing areas) and in offshore waters, so as to assess the horizontal and vertical distribution and movement of nutrients, faecal coliform, algae, dissolved oxygen, salinity, temperature, turbidity, total organic carbon and total solids etc.

7.2. Gulf of Suez
Coastal and marine pollution from fertilizer and chemical industries in Suez should be prevented. Industrial discharges, especially from fertilizers and chemical industries, on a regular basis, should be monitored, to ensure their compliance with local standards, and the criteria set for effluent discharge into the marine environment.

The deleterious effects of continued shoreline alteration, dredging and landfilling on the coastal and marine environment should be prevented. Effective control of the dredging and filling of coastal and marine areas for urban and industrial development, port construction, as well as maintenance and dredging of navigational channels, should be developed and implemented.

A comprehensive monitoring and assessment programme should be established, to provide baseline information with respect to marine environment resources and biodiversity. The programme should deal with two major aspects: coastal oceanographic processes; and assessment of the coastal ecosystems in Suez Canal’s lakes and Gulf of Suez, their biodiversity and productivity.

The proposed development of a free industrial zone at Ain Sukhna with combined port, production, warehousing and transfer facilities will provide ample opportunities for economic growth and employment generation. The use of environmental planning studies and environmental assessments as an integral part of free industrial zone siting, including design and implementation will support their development in an environmentally sound manner. Site selection for the free industrial zone development should recognize the potentially extensive
(direct and indirect) environmental impacts, and measures should be taken to address planning needs both within and outside Ain Sukhna industrial zone.

The establishment of an environmental unit within Suez will allow for “on–site” management of environmental issues by local staff and would make the environment part of “good practice.” This environmental unit should conduct “day–to–day” environmental functions on the basis of formal delegation of responsibility from EEAA. The work of these environmental units should be complemented by oversight activities by the EEAA. The development of the industrial zone of Ain Sukhna should include specific guidelines for the management of emissions and of hazardous and solid waste, including the requirements for associated residential and commercial areas. Environmental management plans for industrial zone should include the use of economic instruments such as fees and fines for emissions, incentives for waste minimization, and pricing of inputs, especially water, that encourages conservation of these resources on a regional level.

Modeling of the Assimilation Capacity of Suez Canal lakes, Suez Bay, and of similar semi-closed water bodies downstream from large Red Sea cities is urgently needed in order to control the quality and quantity of additional effluents into the bay. Major factors are climatic conditions, the current system, and the residence time of water in the bay.

Coastal and marine pollution from the untreated or partially treated sewage should be prevented at Suez Canal's lakes and Suez Canal. Urgent steps have to be taken to enforce safe effluent standards, taking into account internationally agreed guidelines. Wastewater treatment and disposal quality criteria should be established and implemented, and an effluent quality-monitoring programme should be implemented to ensure compliance with the stated discharge criteria and standards. Care should be taken to ensure that the location and design of marine outfall systems to discharge treated effluents into the sea meet the appropriate environmental quality criteria, i.e. avoid the exposure of shell fisheries, water intakes, and bathing areas to pathogens. Also, avoid the exposure of sensitive environments (such as lagoons, bivalve beds, sea grass, etc.) to excess nutrient loads.

Reduction of daily freshwater flows into Suez Canal's lakes and Suez Bay from onshore water discharges. Pressure to divert freshwater flows for urban development will improve marine and terrestrial habitats, if this water is used to cultivate streets and green belts around Suez.

8. References


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