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Modelling of oil spill impacts on shoreline in Egypt

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ABSTRACT: During the last few years, oil spills attracted the attention of both the public and the media, and created a global awareness of the risks of oil spills and the damage they do to the environment. In spite of the recognized great value of the marine environment, it still receives different types of pollutants from different sources. Recognition of spilled oil at sea or on the shoreline may be the first indication of an oil spill. The effect of oil spills can be far reaching, posing both an environmental and an economic threat. Recreational activities, local industry, fisheries, and marine life are among the resources that can be adversely affected by oil spills. The severity of environmental damages caused by oil spillage depends on the quantity and type of oil involved, location of the spillage area/environmental sensitivity, time of year and weather conditions. Egyptian Environmental Affairs Agency (EEAA) implements its own methodology to estimate the environmental and economical impacts as a result of oil spills. According to the EEAA approaches used in Egypt, this paper focuses on and presents the modelling of the shoreline damage assessment in case of oil spills in the Egyptian coastal water.

1 INTRODUCTION

The amount of oil from natural seeps in the world's oceans and from land based sources, riverine transport and runoff, is significant in comparison to the amount spilled from ships. However, a point source of spilled oil creates potentially long term environmental damage to natural resources and ecosystems, which is recognized as "pollution". Pollution means the introduction by Man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harmful to living resources, hazards to human health, hindrance to marine activities, including fishing, impairment of quality for use of seawater and reduction of amenities (Ornitz, 2002).

Oil spills present a unique public dilemma. Statistics indicate that human error causes 80% of the major oil spills. There are many root causes for the reoccurrence of oil spills from tankers' incident operations into the oceans and seas of the world; these can be identified generally as aging world fleet. That is because of the average age of the world fleet, which is over 15 years due to difficult economic conditions for the shipping industry over the past several decades that have produced unintended consequences, except for some of the large major companies, ship owners have not ordered new tonnage, have decreased maintenance, seafarers have become less well trained, multinational and smaller crews, open registers "Flags of convenience", human error, fatigue; and limited trade routes, have all resulted in this. Social and economic developments require economic benefits from selling and transporting oil—"shipping oil". While consumers experience the benefits of the oil available, the negative impacts from the spilled oil are long-term economic, social and environmental impacts. This is in addition to the money spent on the cleanup response, which may be passed on to the consumer in a later time. On a worldwide basis, the size and number of oil spills are declining. As a source, these spills are fortunately less than 5% of the oil pollution in the world's oceans. However, even such a limited percentage from pollution represents a concentrated point source that can significantly affect certain marine ecosystems (Ornitz, 2002).

The oil transporting industry is a global and Flag State based industry that is required to adhere to both national and international regulations and recent changes in public perception. The industry would prefer to have greater limitations of liability for clean-up and to use "natural" restoration processes over for full restoration of the environment. That means that the volume of oil transported will double subsequently and hence the number of oil tankers and oil spills due to the estimated of the world population will double by 2050. However, an international point of view may not be good for ship-owners in the future because of the undergoing change in public acceptance of such damages to the marine ecosystems (Ornitz, 2002).

There are many factors that determine seriousness of impact and speed of recovery; these factors include type and amount of oil spilled and its behaviour once spilled; oil loading (the thickness of deposits on the shore); local geography, climate and season; the biological and physical characteristics of the area; environmental sensitivity; and type and effectiveness of the clean-up response (Dicks, 1998).

2 IMPACT OF OIL SPILLS

The impacts of oil pollution on marine ecosystems varies due to the degree of the oil spilled and the time period of exposure and can be categorized into long term and short term effects. In general, long-term acute and chronic exposure levels are both toxic and hazardous to marine organisms. There is an exception to this rule in the unique situation in coastal areas, or thermal vents where natural long-term oil seeps and methane seeps have existed for many years with resulting specialized ecosystems. Oil poisoning are among the first group due to suffocation oil spills; because oil floats on top of water, less light penetrates into the water, limiting the photosynthesis of marine plants and phytoplankton. Oil spills reduce oxygen absorption of the water, causing oxygen dissolution under oil spills to be even less than the deep sea levels (PMO, 2013).

Spills are not the only pressure on marine habitats; chronic urban and industrial contamination or the exploitation of the resources they provide are also serious threats. Oil spills can have serious effects on marine life, as highlighted by the photos of bird covered with oil which regularly appear in the news after such an event. Such images feed the concept of environmental damage on a large scale lasting after every spill, and cause an inevitable loss of marine resources with serious economic repercussions (ITOPF, 2013).

The oil penetrates and opens up the structure of the plumage of birds, reducing its insulating ability, and so making the birds more vulnerable to temperature fluctuations and much less buoyant in the water. It also impairs birds' flight abilities, making it difficult or impossible to forage and escape from predators. The important thing is the effect of oil on coastal vegetation. Animals that come in touch with high concentrations of oil die of oil poisoning. Worms, microorganisms and young sea creatures are more sensitive. Humans and other animals living near the sea are also threatened. Suspended oil can gain weight by bonding with minerals and settle on the sea floor and harm the ecosystem there. It also causes sediments adherence to the sea floor, destabilizing plants. Usually, it has been observed that sediments begin to move after oil settles on the sea floor (PMO, 2013).

Generally, a large oil spill will poison and kill a great deal of sea creatures in a short duration (in several hours, even minutes). Corpses of fishes and crabs are washed ashore. The presence of toxic components does not always cause mortality, but may induce temporary effects like narcosis and tainting of tissues, which usually subside over time. Long term effects of low concentration pollutions will reveal themselves in a longer duration. Thin oil sheens can dissolve fat soluble poisons such as pesticides and increase their concentration several times higher than usual and more than tolerable for most of the living creatures. Studies investigating the organic components entering food chains show that they persist in living creatures and can pass through several food chains without changing. These compounds, such as pesticides and heavy metals, can be accumulated and finally can be transferred to creatures used as food by humans, and thus they will be accumulated in the human body (PMO, 2013) & (Dicks, 1998).

Generalizations about impacts may not be appropriated and the challenges of understanding begin to sense the effects of oil. Some of these challenges have been articulated by others undertaking the task of rendering at least a portion of the oil impacts universe into something that can be understood, these can be identified as:

- Determining the effects of oil is complex, and generalizing about effects is difficult. One must remember that specific impacts are very species and situation dependent (Boyd, 2001).
- Oil spills will have different environmental effects. The environmental effects will depend on many factors such as type of oil, different oceanographic conditions, latitude, season, and type of ecosystem. This complicates the extrapolation of data in even the most general terms (Ganning, 1984).
- Because many physical and biological processes in the marine and coastal environment are poorly understood, it is difficult for scientists to measure the full impacts of an oil spill, and sometimes the results appear contradictory (Mielke, 1990).
- Many spill impacts have been documented in the scientific and technical literature, and although not all the effects of oil pollution are completely understood, an indication of the likely scale and duration of damage can usually be deduced from the information available. However, it can

be difficult to present a balanced view of the realities of spill effects. The simple reality is that sometimes significant damage occurs, sometimes not (ITOPF, 2013).

- Oil can kill marine organisms, reduce their fitness through sublethal effects, and disrupt the structure and function of marine communities and ecosystems (NRC, 2003).

3 SHORELINE TYPES

3.1 *Introduction*

More than any other part of the marine environment, shorelines (coastline) are exposed to the effects of oil as this is where it naturally tends to accumulate. The degree of oil retention by a shore considerably affects the short-term impact and duration of damage. Retention depends upon the condition of the oil and beach type, e.g. rock, sand, mud flats, coral reefs, and so on. More viscous oils tend to be retained in greater quantities as surface accumulations than less viscous oils. "Broken, uneven and gently sloping shorelines with a large tidal range can hold more oil than steep, smooth shores with a small tidal range". When an oil spill reaches the shoreline as shown in Figure 1, or occurs very near the coast, the phenomena of soiling and coating in oil can have an impact on the populations in the intertidal zone "part of the shore between the furthest limits reached by the tides or foreshore" and the various human activities which take place by the sea. Marine birds and mammals are also obvious victims, such as numerous species of birds feeding on the foreshore at low tide and nesting on the seafront, or marine mammals resting on the shore. However, the algae, fish and shellfish which live in coastal pools, on the rocks and in the sand or mud, are inevitably affected (Dicks, 1998).

Figure 1. Coastline was affected of oil leaked into the Mediterranean Sea (IRIN, 2013).

3.2 *Shoreline types in Egypt*

The type of shoreline is crucial in determining the fate and effects of an oil spill. The structural profiles of different types of shoreline are shown in Figure 2. All types of shorelines are classified in terms of sensitivity to oil spills and ease of cleanup (Fingas, 2000).

A survey of shoreline types in Egypt and their sensitivity to oil pollution has been carried out by the National Oil Spill Contingency Plan (NOSCP) (NOSCP, 1998). The shoreline types in Egypt are classified as.

3.2.1 *Vertical rock/cliffs*

Vertical rocks consist of rock that is largely impermeable to oil, although oil can penetrate through crevices or fractures in the rock. For this reason and because plant and animal life is scarce, bedrock shorelines are not particularly vulnerable to oil spills. If the shore is exposed to wave action and a significant amount of oil is likely to be removed after each tidal cycle. Therefore oil is more likely to be deposited in the upper tidal zone (Fingas, 2000).

3.2.2 *Concrete man-made structures*

Shorelines consisting of man-made solid structures include retaining walls, jetties, breakwaters, piers,

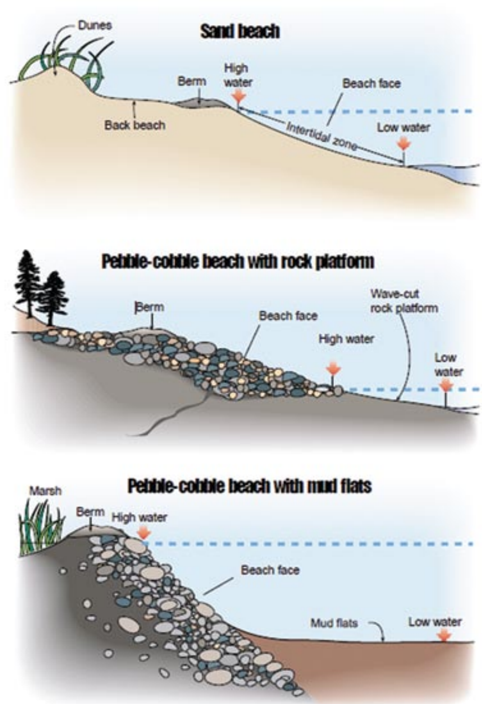

Figure 2. Shoreline profiles (Fingas, 2000).

ramps, and docks, are generally made of rocks, concrete, steel, and wood. This type of shoreline is usually considered impermeable to oil. If the shore is exposed to wave action, a significant amount of oil is likely to be removed after tidal cycle. Man-made structures are the least sensitive of any shoreline to oil (Fingas, 2000).

3.2.3 *Sand beach*

Sand beaches occur in every part of Egypt. On many coasts, they are often located between other types of beaches. Sand is consisting of several different sizes and types of minerals. Only lighter oils penetrate sand beaches and the residence time is likely to be short, except when oil is buried or carried to the upper tidal areas. Oil can easily become buried in sand and over time this can result in layers of sand and oil, referred to as "chocolate layer cake." As sand beaches often do not have a high population of animals or plants, they are not considered particularly sensitive. However, sand beaches are given as most sensitive areas to oil spills (Fingas, 2000) & (NOSCP, 1998).

3.2.4 *Mud tidal flats*

Mud tidal flats are at shallow angles and have a thin, mobile surface layer consisting of water-saturated mud that is impermeable to oil, although oil can penetrate through holes made by burrowing animals. Oil is likely to concentrate on the upper tidal zones. Mud flats are not accessible to vehicles or response personnel and thus cannot be readily cleaned. If left alone, oil is refloated and carried toward land at low tides. Mud tidal flats are important bird habitats and are considered to be sensitive to oil spills (Fingas, 2000).

3.2.5 *Fine grained sand*

Fine-grained sand beaches are generally tourist beaches and tend to retain oil on the surface, as the oil is most likely too viscous to penetrate into the depths through the fine spaces. These beaches consist of material similar to sand beaches but are at shallow angles and never drain completely. They contain a lot of silt or very fine material. The surface layer of sand flats, which consists of a few centimetres, is dynamic and unstable. This surface layer is usually water-saturated and thus impermeable to oils. Oil may accumulate along the high tide mark and be covered over with a layer of clean sand of varying thickness. Beach growth may cause layers of oil to be covered with sand, creating alternate layers. Buried oil is very problematic as the layers of oil may be uncovered by waves and swept away to then pollute other areas. Sand flats are an important bird habitat and are considered to be sensitive to oil spills (Girin, 2007) & (Fingas, 2000).

3.2.6 *Medium coarse sand*

Coarse sand beaches are high risk areas in terms of profound contamination. Coarse beaches are deeper than fine grained compact sandy beaches. Most hydrocarbons can easily enter gaps and flow so deep that it is practically impossible to remove them without seriously damaging the populations living within the sediment substrate. If oil becomes buried in a sandy beach, it is protected from wave action as well as from degradation processes due to the lack of oxygen (Girin, 2007) & (Fingas, 2000).

3.2.7 *Exposed beach rock*

Rocky coasts or exposed beach rock, steep rocky coasts provide an ideal surface to which large quantities of oil can stick. They are fairly quickly cleaned by the mechanical effect of subsequent wave action, and therefore suffer relatively little from oil spills. Rocky outcrops, which may be submersed at high tide or in heavy swell, can be more severely affected, especially if the outcrop contains rock pools rich in flora and fauna, where thick layers of oil are likely to accumulate (Girin, 2007).

3.2.8 *Pebbles/cobbles beach*

Pebble-cobble beaches consist of fine materials. These materials may be present in the interstitial areas between pebbles and there may also be large boulders in the area. Oil readily penetrates pebble-cobble beaches through the open spaces between the rocks. Retention of the oil may be low as it is often flushed out from the interstitial areas by natural tide or wave action. Oil will likely concentrate on the upper reaches, however, where there is little flushing action. As wave action constantly rearranges or reworks the sediments, few animals and plants are present, especially in the middle intertidal zone. Pebble cobble beaches are not considered a sensitive beach type (Fingas, 2000).

3.2.9 *Boulder beach*

Boulder beaches consist primarily of materials. These beaches are not altered by any conditions other than ice, human activity, or extreme wave conditions. Boulder beaches often give way to mud or sand tidal flats in the lower intertidal zone such as an international shoreline. Because of the large spaces between individual boulders, oil can be carried down to the sediments and remain there for years. Since animals and plants live in these spaces, oil often has a severe effect on boulder beaches. Boulder beaches are considered to be moderately sensitive to oil and do not rapidly recover from oiling (Fingas, 2000).

3.2.10 *Mangroves*

Mangroves are tropical trees characterized by complex, interlaced root systems, parts of which are aerial and provide means for the trees to breathe. The term "mangrove" also refers to the complex ecosystem of which the mangrove tree is the most important component. This ecosystem can include sea grasses and many specialized organisms that are interdependent. Mangrove stands are highly productive areas and they provide habitats for a large variety of organisms as well as serving as a nursery ground for many fish and crustacean species. Mangrove trees commonly die when oiled, thus resulting in loss of habitats for dependent species. Oil coats the respiratory roots of mangrove trees and kills the tree within a few days. Damage is effected either through the coverage of breathing spores on the aerial root systems or through oil penetration of the sediments. Many of the organisms in a mangrove ecosystem are sensitive (Fingas, 2000) & (NOSCP, 1998).

3.2.11 *Marshes/saltmarshes*

Marshes are important ecological habitats that often serve as nurseries for marine and bird life in the area. Marshes range from fringing marshes, which are narrow areas beside a main water body, to wide salt marsh meadows. Marshes are rich in vegetation that traps oil. Light oils can penetrate into marsh sediments through animal burrows or cracks. Heavier oils tend to remain on the surface and smother plants or animals. Oiled marshes, fresh or salt, may take years or even decades to recover. Oil quickly and severely affects the populations of invertebrates living in the sediment, and the parts of plants in contact with the water. Marine marshes in temperate areas, like tropical mangroves, are particularly sensitive to oil pollution. The respiration of the aerial roots of mangrove trees can be seriously impaired by even a thin lens of oil. They are considered sensitive to oiling (Girin, 2007) & (Fingas, 2000).

Saltmarsh meadows often flood only during high tides in spring or during storm surges. Saltmarshes are extremely productive and are valuable habitats for many species, especially birds. Most marsh areas in Egypt are enclosed within the lakes on the Mediterranean coast, which are only connected to the sea through narrow gaps, but are sometimes found in conjunction with mangroves. Saltmarshes are oil traps and recovery times from oiling vary widely, from one or two years to decades. Thus the protection of saltmarshes (where they occur) is a high priority. The emphasis will be on booming the inlets to protect threatened marsh areas. Saltmarshes are also sensitive to oil pollution (Girin, 2007) & (NOSCP, 1998).

3.2.12 *Coral reefs (raised fossil reefs and exposed reef flats)*

Coral reefs are highly productive areas which support a diverse group of organisms, including many commercial fish species. In Egypt they are often associated with commercially important dive sites. Coral reefs are easily damaged if oiled, may take several decades to recover if killed, and are difficult or impossible to clean. The susceptibility of coral reefs to oil damage depends on a number of factors: e.g. size of spill, type of oil, type and depth of coral reef, the local wave energy, the current stress of the corals, etc. In many cases oil slicks will float over reefs without causing damage to the submerged corals and associated organisms. Biological productivity per square meter of coral reef is usually 50 to 100 times more than in the surrounding oceanic waters. On a local scale, reef areas are an important fishery resource, are a barrier to coastal erosion, and their amenity value is often the basis of tourism development. Serious damage to corals can result from oil pollution, coral reefs are considered most sensitive to oiling (NOSCP, 1998).

4 METHODOLOGY FOR SHORELINE DAMAGE ASSESSMENT IN CASE OF OIL SPILLS IN THE EGYPTIAN COASTAL WATER

According to Egyptian law No. 4 for the environment protection in 1994 and its amendment law No. 9 in 2009, the EEAA considers that polluters should pay compensation for environmental damage; (this compensation does not include the clean-up of shoreline, which can be fixed case by case during the clean-up process). The EEAA formula or methodology for shoreline damage assessment from oil spill is shown in equation 1:

Oil factor * oil spill size * environmental sensitivity * length of the impacted coastline /shoreline (1)

The compensation for environmental damage is calculated according to a certain formula given by EEAA as stated above in equation 1, which in turn includes the following factors: oil factor, the size of the spill, the environmental sensitivity of the area affected and the length of the shoreline impacted. These factors can be identified as:

1. Oil factor: For oil spill response purpose, oils are generally divided into five groups (Table 1). These are based largely on the "American Petroleum Institute: API Gravity" and oil's density or "Specific Gravity: SG" (EEAA, 2011) & (WA, 2010).

   Here is a description of five groups of oil according to EEAA:

   Grade No. I: Light Oil Products, Volatile or Products of washing tanks; these products

Table 1. Definition of oils based on API gravity.

Group	API gravity	Specific gravity	Viscosity: cSt @ 15 ºC
I	>45	<0.8	0.5: 2.0
II	35: 45	0.8: 0.85	4: solid (Ave = 8)
III	17.5: 35	0.85: 0.9	8: solid (Ave = 275)
IV	<17.5	0.95: 1.0	1500: solid
V	<16.0	>1.0	High

dissolve in water and contain harmful substances and too many harmful components.

Grade No. II: Crude Oils or Light Oil Products; these products contain harmful components that remain on the water surface or dissolve in water greatly.

Grade No. III: Oils or Heavy Oil Products; these products do not dissolve in water and are frozen immediately, once mixing with water, and their impact on the shores is very harmful.

Grade No. IV: Oils or Medium Oil Products; these products contain harmful components that dissolve in water with little proportions.

Grade No. V: Oils or Heavy Oil Products; these products do not dissolve in water but may be frozen and their impact on the shores is the largest (EEAA, 2011).

2. Size of the spill (volume factor): The amount of oil spilled is clearly an important factor in determining pollution damage. Thus, given no variation in other factors such as type of oil, location and economic resources at risk, a 50,000 tonne spill will result in far wider contamination, will require a far more extensive clean-up response and will cause greater damage than, say, a 2,000 tonne spill. This emphasises the inappropriateness of simplistic comparisons between the costs of individual spills based on the single parameter of spill volume (White, 2002).

   The range or applied limits of the size factor in the above formula is divided into six groups. Here is a list of those six groups respectively; Group One: when the amount of spillage is less than 100 tonnes, Group Two: when the amount of spillage is between 100 and 500 tonnes, Group Three is when the amount of spillage is from 500 to 1,000 tonnes, Group Four is when the amount of spillage is between 1,000 and 1,500 tonnes, Group Five is when the amount of spillage is from 1,500 to 2,000 tonnes, and Group Six is when the amount of spillage is more than 2,000 tonnes. Unfortunately, such spurious extrapolations are often made in an attempt to justify the level of claims for clean-up costs or alleged damage in a new incident (EEAA, 2011).
3. Environmental sensitivity: a term used to describe the susceptibility of environment sensitivity of shoreline to any disturbance that might decrease its stability or result in short- or long-term adverse effects. Environmental sensitivity generally includes physical and biological factors. Shorelines that are susceptible to damage from spilled oil are usually equally sensitive to cleanup activities, which may alter physical habitat or disturb associated flora and fauna. Marshes and lagoons are the most sensitive shoreline environments, while exposed coastline subject to heavy wave action is generally the least affected by oil and cleanup activities (Fingas, 2000).

   According to EEAA investigations, there are five sensitivity factors ranging from 2 to 6 depending on spill location. Here is a list of those five sensitivity factors respectively; Factor 2 when pollution occurs in environmentally insensitive port areas, Factor 3 when pollution occurs in territorial waters in Mediterranean Sea, Factor 4 when pollution occurs in areas of lakes, Factor 5 when pollution occurs in areas of Red Sea and the Gulf of Suez., and Factor 6 when pollution occurs in Gulf of Aqaba and Coral reef areas and River Nile (EEAA, 2011).
4. Length of the shoreline impacted: It is the length of the shoreline impacted when pollution occurs due to oil spillage. According to a study of the length of shoreline, the range or applied limits of shoreline length factor in the above formula are divided into six divisions. Here is a list of those six divisions respectively; firstly less than 1 km, from 1 to 5 km, from 5 to 10 km, from 10 to 15 km, from 15 to 20 km, and finally more than 20 km (EEAA, 2011).

5 MODELING STRUTURE

This paper focuses on and presents the modelling of the shoreline damage assessment in case of oil spills in the Egyptian coastal water based on the EEAA methodology. The proposed Oil Spill Damage Assessment Model (OSDAM) was designed as an oil spill support tool for emergency responders and contingency planners to estimate the economical and environmental impacts as a result of oil spill in coastal water of Egyptian. Figure 3 shows a snap shot of the Oil Spill Damage Assessment Model.

The data base of OSDAM contains a wide range of common oil types, in addition to the fact that if the type of oil spilled is not found in the data base, the user can put the specifications of the oil spilled into the program himself, which is called in the model (Custom Oil). Figure 4 shows a snap shot of OSDAM environmental damage assessment.

This paper aims to formulate the EEAA methodology to assess the environmental impacts in shorelines in Egypt using OSDAM program. Figure 5 is a snap shot from the OSDAM data entry screen.

This version of OSDAM is implemented to estimate the environmental damage for different types of environmental features and it was designed to be fed with as little information as possible which can quickly be obtained in the field of incident.

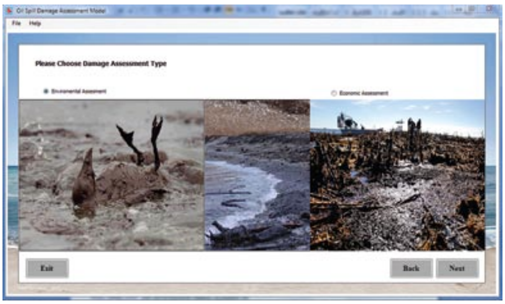

Figure 3. Snap shot—Oil Spill Damage Assessment Model.

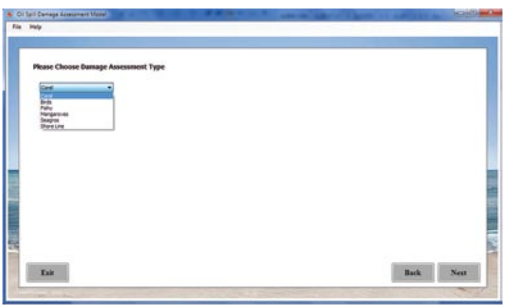

Figure 4. Snap shot—OSDAM environmental damaged assessment.

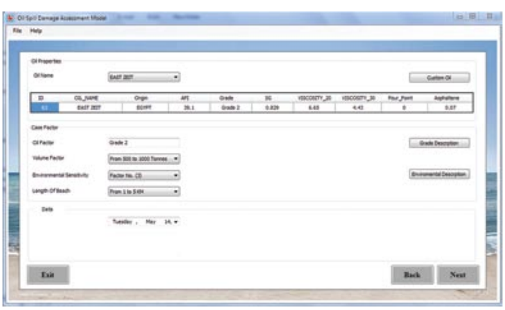

Figure 5. Snap shot—OSDAM data entry screen.

To run OSDAM, responders and planners need to select the appropriate oil type, enter the information about the environmental damage occurring, select the amount of oil spillage range, select the environmental sensitivity, and choose the length of the shoreline impacted.

OSDAM includes an oil database that is sorted by APIs or names. The model supports customizing any new oil type by feeding it with its physical and chemical properties.

Responders and planners choose the impacted environmental feature; this paper shows only the shoreline damage assessment methodology.

6 ASSUMPTIONS & IMPLEMENTATION FOR SIMULATED SCENARIOS

Responders and planners feed the OSDAM model with the appropriate input data. Two assumed scenarios of shoreline impacts assessments were investigated by the OSDAM model and the assumed data are shown in Table 2.

The total damaged assessment for scenario 1 and scenario 2 is shown in Figures 6 and 7.

The OSDAM estimates the shoreline damage not only for one shoreline type (scenario 1) but also for multiple shorelines types (scenario 2).

Scenario 1: the model fed with the following inputs: East Zeit oil type from Egypt its API is 39.1, the

Table 2. Shows the two scenarios of shoreline impacts.

Inputs	Scenario 1	Scenario 2
Oil type—origin—API: (oil factor)	East Zeit—Egypt—39.1	East Zeit—Egypt—39.1
Total amount of spilled oil: (volume factor)	1500 Tonne	1500 Tonne: a. 450 tonne b. 80 tonne c. 970 tonne
Environmental sensitivity: (sensitivity factor)	Territorial waters: 3	a. Territorial waters: 3 b. Lakes: 4 c. Red Sea & Gulf of Suez: 5
Length of shoreline	4 km	a. 4 km b. 1 km c. 6 km
Total damaged assessment		
Min	900,000 L.E or 128,571 $	1,950,000 L.E or 278,571 $
Max	9,000,000 L.E or 1, 285,714 $	19,500,000 L.E or 2,785,714 $

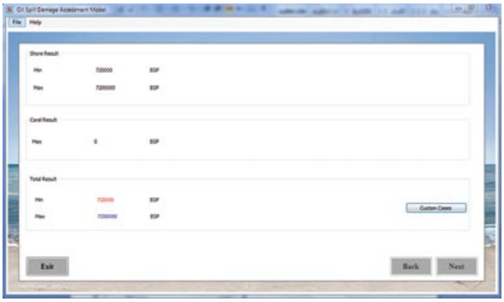

Figure 6. OSDAM total damaged assessment for scenario 1.

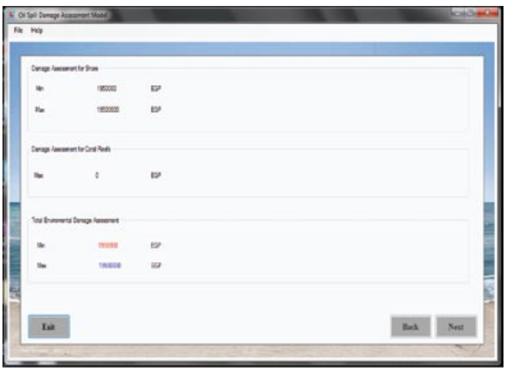

Figure 7. OSDAM total damaged assessment for scenario 2.

total amount of spilled oil is 1500 tonnes, the Environmental Sensitivity as Territorial waters is 3 with shoreline length is 4 km. The model assessed the maximum damage as 9,000,000 L.E or 1, 285,714 $ while the minimum damage as 900,000 L.E or 128, 571 $.

Scenario 2: the model simulates the shoreline damage assessment for multiple shorelines types, the OSDAM fed with the same East Zeit oil type and the same total amount of spilled oil is 1500 tonnes divided into 450 tones stranded on territorial waters for 4 km which is ranked as 3, while 80 tonnes reached along a lake for 1 km which is more sensitive and ranked as 4, finally 970 tones impacts 6 km from a high sensitive area like the Red Sea and Gulf of Suez which is ranked as 5. The model assessed the maximum damage as 19,500,000 L.E or 2,785,714 $ while the minimum damage as 1, 950,000 L.E or 278,571 $.

7 CONCLUSION

Egyptian shorelines are sensitive coastal environment threatened by numerous anthropogenic activities due to production and world trade transport of oil and its products. This paper presents a technological tool (Oil Spill Damage Assessment Model (OSDAM) for assessing the impacts of oil spill on the different types of shoreline type. This model facilitates the calculations for the environmental damage assessment for the planners and assessors in case of oil spills in the Egyptian coastal water based on the EEAA methodology.

REFERENCES

Boyd John N, Scholz Debra, Hayward Walker A. Effects of Oil and Chemically Dispersed Oil in the Environment. International Oil Spill Conference Proceedings (IOSC): March 2001, Vol. 2001, No. 2, pp. 1213–1216.

Dicks, Brian 1998. The Environmental Impact of Marine Oil Spills—Effects, Recovery and Compensation. The International Seminar on Tanker Safety, Pollution Prevention, Spill Response and Compensation, 6th November 1998, Rio de Janeiro, Brasil.

EEAA Resolution, 2011. Ministry of State for Environmental Affairs (MSEA)—Egyptian Environmental Affairs Agency (EEAA). Resolution No. 167–2011, Issues 22 March 2011.

Fingas, Mervin. 2000. The Basics of Oil Spill Cleanup, Second Edition. Boca Raton, Florida: Lewis Publishers.

Ganning, B., Reish, D.J., Straughan, D., 1984. Recovery and Restoration of Rocky Shores, Sandy Beaches, Tidal Flats, and Shallow Subtidal Bottoms Impacted by Oil Spills. vol. 7. Boston: Butterworth Publishers.

Girin, Michel. 2007. Understanding Black Tides. CEDRE: Centre of Documentation, Research and Experimentation on Accidental Water Pollution, 29218 Brest—July 2007.

IRIN: The Integrated Regional Information Networks, 2013. http://www.irinnews.org/Report/70043/LEBANON-Long-term-environmental-challenges-ahead, accessed April, 2013.

ITOPF: International Tanker Owners Pollution Federation, Marine Spills, http://www.itopf.com/marine-spills/, accessed February 2013.

Mielke J.E., 1990. Oil in the Ocean: The Short- and Long-term Impacts of a Spill. Volume 90, Issue 356 of CRS report of Congress Washington, DC: Congressional Research Service (CRS).

NOSCP, 1998. National Oil Spill Contingency Plan (NOSCP) for Egypt. September 1998.

NRC: National Research Council, 2003. Oil in the Sea III: Inputs, Fates, and Effects. Washington, DC: National Academies Press.

Ornitz, Barbara E. & Champ, Michael A., 2002. Oil Spills First Principles: Prevention and Best Response. 1st ed. UK: ELSEVIER SCIENCE Ltd.
PMO: Port & Maritime Organization, 2013. Maritime Protection, Environmental Effects of Oil Spills on Marine Ecosystem. http://bushehrport.pmo.ir/en/maritimeenvironment/coastalmarine. Accessed March 2013.
WA "Western Australia". 2010. WA OIL CLASSIFICATION. Department of Transport Oil Spill Contingency Plan (OSCP), Appendix D, Issues June 2010.
White, Ian. C. 2002. Factors Affecting the Cost of Oil Spills. The Gulf Area Oil Companies Mutual Aid Organization: GAOCMAO Conference, Muscat, Oman, 12–14 May 2002.