Oil Spill Response Information System and Contingency Planning for Guinean Waters

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Abstract

Over the years there has been many well documented cases of major oil pollution from leaked offshore oil rigs, ships in distress and from coastal oil facilities. In response to concerns about the possibility of a major oil spillage occurring along the coast of Guinea, the Guinean government drew up a plan and organisation. The purpose of this research was to develop Guinean Marine Oil Spill Response Information System. To do this, we simulated an oil spill concentration transport. The results show that the numerical model in oil spill accident simulation is important in allowing setting up of possible response and contingency planning. From the results we conclude that, the search strategies for futures responses and contingency planning to possible oil spill case in Guinean coasts has been clarified. Implications of research findings allow international community to consider reasonable estimation of spilled oil trajectory with limited environmental input data.

Keywords: Guinean waters; Oil spill; Contingency planning; Response system; Models

1. Introduction

Guinea is confronted with potentially serious pollution of marine/coastal habitats and resources. In order to safeguard the Guinea marine environment against current oil spill risks and other forms of pollution, the country has adhered to several regional assessments that examined environmental issues in the West and Central African region (WACAF). According to the International Tanker Owners Pollution Federation Limited (ITOPF) 2000; the competent body for maritime affairs in Guinea is the General Directorate of Marine Merchant. By a government Decree in 1981, the National Centre for the Protection of Marine Environment, a body within this directorate, was created to deal specifically with marine pollution matters. Effective response to oil spill requires marshaling critical information in real-time, often for sustained period of days-to-weeks and over a wide spectrum of topics, including surveillance data, environmental conditions, ecological factors, and countermeasures options (both from a technical and a legal perspective) (Meyers et al., 1989). A high degree of organization and preparation is required.
to support these needs effectively (Jensen & Tebeau, 1991). The same basic information system should be able to support both tactical and strategic needs (Harrald et al., 1990).

Thus, the oil spill information system, which serves as a decision supported system and the main component of the contingency and response plan, play an important role in dealing with the environmental damage caused by oil spills in order to more effectively manage the risks associated with accidental oil spill releases into the coastal environment. In this paper, a Marine Oil Spill Response Information System (MOSRIS) was developed to aid emergency responders in identifying, responding and mitigating the effects of oil spill incidents in the Guinea waters and coasts.

2. Marine environmental conditions

Guinea is characterized particularly by its hydrological situation with the presence of most of basins of the West African rivers. The geographical coordinates of the continental shelf are: longitude between 13°19' and 17°00’ and latitude between 9°02' and 10°50’. The area has an average width of 80 miles and in its northern part it reaches 110 miles. It extends from 0 to 200 m in depth (Domain 1989). This Guinean marine environment is subject to a strong continental influence. From December to May the surface temperatures remain fairly constant, close to 27°C. The warm hydrological season is the rainy season (June to November), during which the continental freshwater contributions due to high rainfall are important. This season is characterized by relatively constant sea surface temperatures between 26°C and 29°C (Domain et al., 1999). Relative humidity ranges between 49.6 and 97.8% with 2 to 8.6 hours of sunshine daily, depending on the season (Baran, 1995).

Sensitive resources are the ecosystems and their marine and coastal resources. These ecosystems are characterized by sandy beaches and the vast areas of mangroves with places of hatching and niches for a range varied species of fish, shrimps, mollusks and many other coastal species.

3. System architecture

The components of the Oil Spill Incidents Contingency and Response System in this paper include: the transport model, the 3D-hydrodynamic model, the environmental database and oil spill location, response options database, oil characteristics database and system functions for data input, model execution, end results and measures of success.
4. Numerical models

4.1 Hydrodynamic model

The hydrodynamic marine model is based on a 3D free-surface non-hydrostatic equation system (Zalesny et al, 2004). A high-resolution circulation model describing the complex hydrodynamics of coastal waters is required to provide appropriate flow fields. For this purpose, the sigma-coordinate primitive equation Princeton Ocean Model (POM) (Blumberg and Mellor, 1987) has been employed. The dynamic equations are solved by using a finite differences approximation on 3D, regular space-staggered grid system. To provide the prevailing conditions of the tidal current, the exoteric boundary condition using the data from the exoteric station was established by a conciliatory method, in which the movable boundary is dealt with by the “dry-wet” method. Then the simulation models are computed by the ADI method. The unison constants are saved in the form of layer databases for the purpose of quickly predicting tidal currents.

4.2 Transports and fate model

Trajectory analysis is most commonly carried out to support real time or tactical spill response. The transport and fate of spilled oil in water bodies are governed by physical, chemical, and biological processes that depend on the oil properties, hydrodynamics, meteorological and environmental conditions. When liquid oil is spilled on the sea surface, it spreads to form a thin film of oil slick. The movement of
the slick is governed by the advection and turbulent diffusion due to current and wind action. Light (low molecular weight) fractions evaporate, water-soluble components dissolve in the water column, and immiscible components become emulsified and dispersed in the water column as small droplets (Tkalich et al., 2003).

The formation of oil-in-water or water-in-oil emulsion depends upon turbulence, but usually occurs within days after the initial spill. It forms thick pancakes on the water then after a long time; this may disintegrate into lumps of tar. Tar balls and oil pancakes present a small surface area compared with their volume and for this reason degrade extremely slowly. Given enough time, the combined actions of weathering and biodegradation can eliminate most of the spilled oil. Oil may wash up on beaches or into biologically sensitive tidal areas or estuaries, causing severe damage (Tkalich et al., 2003). In this study, the formula developed by (Stiver and Mackay 1984) was used. The Mackay model is used to describe emulsification, which is defined as a function of wind speed, the oil’s water content, and an oil-specific constant. If a parcel is moved onto land, then that parcel is considered beached and takes no further part in the simulation.

Figure 3 Oil spill total area duration 24 h. and timestep 6 h. in 5 cm/s wind and spreading coefficient is 0.5 k

Figure 4 Oil spill area of thick in km² duration 24 h. and timestep 6 h. in 5 cm/s wind and spreading coefficient is 0.5 k

Oil spill total area is many square km² with duration 24 h. / time step 6 h. in 5 cm/s wind and spreading coefficient is 0.5 k. This is shown in figures 3 and 4. From that we simulated the oil concentration and thickness oil concentration (ppm) surface contaminant/thickness.
Figure 5 presents the mass of oil over time for various simulations. For quick effectiveness mechanical response in 5 m/s wind gives an important finding for the removal of oil from the Guinean water surface in case of oil spill incidents.

Figure 6 below shows oil concentration of sediment contaminant over time for two search criteria (closest/thickest oil in others words 4 and 5) and one value for number of particles 500. The highest effectiveness is obtained by searching for the closest oil (search criteria 5). The reason for this is that by moving the equipment to the closest contaminant having a thickness over a certain limit, instead of moving to the overall thickest contaminant, less time is spent moving the equipment between contaminates and more time spent recovering oil. The search criterion 5 is also more robust with respect to variations in the number of contaminates. However, the distance to the overall thickest contaminant will on average be the same. Thus, search criteria 4 depend strongly on the number of contaminates.
The simulation of fish eggs and larvae area concentration volume which has been exposed to the contaminant over PNEC (Predicted No-Effect Concentration) of the cut-off value for effects can be seen in this figure.

5. Spill transport simulation

On the basis of what happened at the Shell Forcados Terminal, Nigeria in 1979, when 580,000 barrels of oil leaked into the delta, damaging vast areas of mangrove forest and rivers, we simulated an oil spill incident with the oil leaked in Guinean coasts and developed a Marine Oil Spill Response Information System for Guinean waters.
6. Response and contingency planning

Providing a safe, prompt and efficient response lies in the expertise of people to solve problems and understanding the issues surrounding oil spills and the preparation of equipment. In Guinea, the National Centre for the Protection of the Marine Environment (CNPMM) has prepared an outline national oil spill contingency plan, but this is still at the draft stage. In the event of a major spill the CNPMM would coordinate all clean-up activities. The coastline of Guinea is largely dominated by low-lying swamps and mangroves, both are difficult shoreline types on which to mount a clean-up operation. Manual clean-up may be undertaken on the limited areas of sandy beach. Guinea has limited, basic resources available for dealing with oil spills. There is general port equipment, agricultural equipment, and a large labor force; but there are no specific resources in the country to deal with an oil spill disaster.

7. Conclusion and recommendations

The simulation gave a reasonable estimation of spilled oil trajectory with limited environmental input data. To improve the efficiency of the response decision support, an intelligent decision support system (IDSS) should be developed based on the oil spill response database. After oil spill the simulation from oil leaked according to the Nigerian situation in 1979, the parameters were selected that allow us to obtain the conclusions from oil Spill Contingency and Response Model System for Guinean Waters: The oil spill t area of in km² with duration 24 h. and time step 6 h. in 5 cm/s wind and spreading coefficient is 0.5 k; the corresponding information of oil recovered area over time for some values; water surface exposure over time for one value and mass of oil over time for some values; all of these realities for quick effective mechanical response in 5 m/s wind. This gives an important contribution to the removal of oil from the Guinean water surface in case of oil spill incidents; the water risk for possible chemical response after spillage; oil concentration of sediment contaminant over time for two search criteria (closest/thickest oil); and the essential time limit to protect fish eggs and larvae exposed to oil contaminant from biological effects.

The model can be used to support the decision-making process after a pollutant is released in the area. Guinea is preparing for future oil exploitation on its coasts; in this way, the Government and oil industry authorities must take all reasonable precautions to minimize the risks of oil pollution due to possible oil spill incidents in the country’s waters; at the same time striking a balance between protection of the marine environment and maintaining profitable sea routes.

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References


