Need For Coastal Water Management Tool For Oil Spill Simulation In Ghana

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Abstract: Ghanaian water bodies have been under threats recently, ranging from illegal mining, sand winning, reclamation of water bodies for the purposes of human settlement, pollution, etc. Civil and mechanical installations on the coastal waters have increase due to the discovery of oil recently and such situations are not spared by oil spills. Oil spills are an inevitable consequence of the need to produce, store, and transport oil. The commercialization of oil production has placed Ghana among High-Risk Zones which are characterised by high traffic density and the presence of navigational hazards. Despite Ghana's awareness about oil spill accidents in both preparedness and response, it is likely it will be compromised when any accident occurs as it has more pressing demands on finite funds and resources. This situation might place Ghana among ill-prepared countries against oil spill combat. An important part of contingency plan is the prediction of locations that are susceptible to oil after spillage. This can be done by the use of satellite information, reviewing and comparing previous incidents, laboratory work or by fine tuning models which as of now the country is not having despite all the precautions to prevent oil spills. When spill models are used properly, they provide ecological, economic and social benefits. Hence, the need for such decision-making tool for Ghana to create an environment for the contingency plans to be tested, validated and upgraded. Such exercises not only maintain and increase the skills of the response personnel, but also lead to improvements and fine tuning of the plan as weaknesses and gaps are identified.

Keywords: oil spill, contingency plan, Risk Assessment, Response actions, Vulnerability analysis, pollution, susceptibility

Introduction

Oil is a necessity in our industrial society and any accident evolved around it equally calls the attention of the public and the media. It is now obvious that, the production and consumption of oil and its derivatives, and oil pollution are increasing accordingly [1], [2]. Human activities and natural oil seepage [3], [4], [5] form the principal processes that marine environment can get polluted through crude oil. Oil spill accident, a major cause of oil pollution through human activities in the environment can occur at any time of exploration, production, storage, transportation and utilization of petroleum. Though it is believed that most spilled oil or oil pollutants are often as a result of accidents on the sea, "about half of it is from runoff of oil and fuel from land-based sources, usually from water waste" [2]. When a petroleum product is accidentally or intentionally released into the environment as a result of human activities the result is called an oil spill. Several methods have been introduced to study the movement of oil and ways to carry out optimal clean-ups on oil particles in the marine environment. May be an important aspect of oil spill which has made it a public spectacle is the devastating effects to the environment which cannot be underestimated [3], [2], [7], [8], [9]. In the wake of any oil spill, the main intended results for response are both to minimise the damage to environmental and socio-economic resources, and to reduce the time for recovery of affected resources [2]. What is more; a good way of dealing with any emergency is to be prepared.

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Therefore, planning for an oil spill emergency helps minimise potential danger to human health and the environment by ensuring a timely and coordinated response because it most often covers many different spill scenarios and addresses many different situations that may arise during or after a spill [10], [2], [11]. This is called contingency plan.

Importance of contingency plan

Well-developed contingency plans can assist response personnel in their efforts to control, contain and clean up oil spill by providing information that the response team will need before, during and after spills, and also provide information on what might go wrong with provision for attack to reduce any bad environment impact [10]. Although many contingency plans are different in many respects they have two main similarities; Risk assessment and Response action. Risk assessment part of the contingency plan is used by planners to draw specific response actions during oil spill attack.

Components of contingency plan

The risk assessment section identifies the location of oil, hazardous substances; where oil is stored, the corridors through which it travels, the locations of industries that use large quantities of oil and if possible stating their handling capacity, and the location of response equipment and personnel trained to use the equipment and respond to the spill. The risk assessment also identifies information about resources and locations. Vulnerability analysis information might include the following: Lists of public safety officials in the community, lists of facilities such as schools, nursing homes, hospitals, and prisons, lists of recreational areas, such as campgrounds, lists of special events and when they take place, and identification of parts of the environment that are particularly susceptible to oil or water pollutant. Risk Assessment helps contingency planners compare the hazard posed by pollution and the vulnerability in a particular location to see the kind of risk that is posed to a community after close analysis. The Risk assessment section of the plan then addresses those problems by determining how best to control the spill, how to prevent

certain populations or environments from exposure to oil, and what can be done to repair the damage done by the spill. Response actions are developed to address the risks that are identified in the risk assessment. A carefully designed contingency plan will describe major actions that need to be taken when a spill occurs. These actions should take place immediately following a spill. The following response actions should be included in a contingency plan: list of all companies or government agencies that are responsible for the cleanup effort, getting trained personnel and equipment to the site quickly, defining the size, position, and content of the spill; its direction and speed of movement; and its likelihood of affecting sensitive habitats, ensuring the safety of all response personnel and the public, stopping the flow of oil from the ship, truck, or storage facility, if possible, and preventing ignition, containing the spill to a limited area, removing the oil, disposing of the oil once it has been removed from the water or land.

Resource susceptibility to oil spill

The most important part of contingency plan is the formulation of the Risk assessment section, for predicting the locations that are susceptible to oil spill pollutants [12]. This can be done either by the use of satellite information, reviewing and comparing previous spill cases or use of numerical models [13], [14], [15]. The success of these models has been mixed. In some cases, cleanup personnel have preferred to rely on industry rules-of-thumb over computer models, since the latter could prove difficult to use and be unreliable in their answer. Lately, however, computer software has become easier to use and more realistic in its predictions [16]. Although, satellite information provides the best results for such predictions numerical models helps responders to carry out several spill scenarios and interactive-training sections.

National Oil Spill Contingency Plan (NOSCP) – Ghana

Oil and gas discovery in commercial quantities in Ghana was announced in 2007 [17]. Since then the country has been mandated to draw ways to prevent and deal with environmental challenges that might arise because of exploration, transportation and the likes. Whiles Ghana enjoys the benefits of oil and gas; economic growth and social development, the country is yet to record its first major inevitable oil spill and the likes. For this and more; operations that have the potential for a variety of impacts on the environment which destruct the ecological system from performing their functions, has made The Environmental Protection Agency (EPA) Act 490 of 1994 to empower EPA, Ghana, to perform several functions relating to the protection of the environment; prohibits any deliberate discharge of oil or oily mixtures from their operations in Ghana, hence, the formulation of the National oil spill contingency plan (NOSCP). National Contingency Plan has been in existence since 1986 and brings together various resources and equipment for tackling accidents in a pool, to create a well-prepared environment in case of any threat to the environment by oil and chemical spills. The importance of the plan cannot be overemphasised; arrangements for responding to oil spills accidents, and minimising its impact in the environment. Thus, the objectives of this plan are to:

i. Identify high-risk areas to oil pollution
ii. Develop appropriate systems for monitoring, rapid detection and reporting of spillage of oil or incidents related to the operation of shipping, oil pipelines and all other installations, storage and transport facilities for oil, which could result in such a spillage.
iii. Ensure prompt response to prevent pollution and or restrict the spread of the contaminants
iv. Ensure that adequate protection is provided for public health and welfare and the marine and inland environment.
v. Ensure that the appropriate response techniques are used to clean up the pollutant and that disposal of recovered material is carried out in accordance with the EPA guidelines and regulations on waste disposal.
vi. Ensure that complete and up-to-date records are maintained of all expenditures to facilitate cost recovery.
vii. Ensure that personnel and equipment are in a state of readiness
viii. Ensure that there are adequate funds provided to meet the other objectives of the plan.
ix. Ensure that the plan is tested at least every two years

The various sections of the outlined objectives are to conserve the environment, hence the need to investigate the trajectory and fate of oil particles in the territorial waters of Ghana. The state of objectives i, ii, vii, and ix have poorly left the plan in a poor state. It is therefore mandatory for research institutions to help. The geographical domain for protection from oil spill particles covers all Ghanaian Territorial Seas including Ghana's Exclusive Economic Zone, and the High Seas, where environmental accidents have the potential to impact on Ghanaian interests as detailed in Figure 1.

Figure 1: *Geographical Area*

During operations, every effort is made to prevent accidental oil spills through careful attention to fuel management and transfer operations, and by maintaining storage facilities to a high standard. Oil spill contingency procedures are required in case accidents happen in spite of precautions which the country has as at now.

Oil Spill Trajectory Prediction (where will the oil go)

The purpose of contingency plans includes stopping the flow of oil, containing the oil, and cleaning it up.

Environmental emergencies can occur anytime because they are not predictable. Therefore, effective response to an oil spill is to be prepared. When oil is spilled, number of biogeochemical processes occurs they are referred to as the "behaviour" of the oil. The first is weathering. Weathering process causes the physical and chemical properties of the oil to change after the spill. The second is the movement of the oil in the environment. The specific processes that occur after an oil spill, determine how the oil should be cleaned up and its effect on the environment. These processes are entirely determined by the type of oil and the environmental conditions at the time of the spill. Spill responders need to know the ultimate fate of the oil to take measures on how to minimize the overall impact of the spill. After an oil spill in the environment, the oil tends to spread into a slick over the water surface. Critical question responders ask, where will the oil go? In any oil spill accident, deciding how best to protect resources and direct cleanup by responders and decision-makers is a guidance provided by how best they know the trajectory of the spill particles. Oil spill trajectory and fate models have been developed to predict and simulate oil spill particles movement in the environment in advance. Literature has shown that contingency plans have evolved and today often cover wide areas including simulation of oil spill fate and trajectory to create interactive training sections without polluting the environment. This interactive training varies from a "tabletop" exercise to large-scale field exercises in which equipment are deployed and oil is actually "spilled" and recovered. All these to create an environment for the contingency plans to be tested, validated and upgraded. Such exercises not only maintain and increase the skills of the response personnel, but also lead to improvements and fine tuning of the plan as weaknesses and gaps are identified. Today's sophisticated spill models combine the latest information on oil fate and behaviour with computer technology to predict where the oil will go and what state it will be when it settles. Their major limitation to accurately predicting an oil slick's movement is the lack of accurate estimates of hydrodynamic processes and atmospheric forces along the predicted path. This is likely to remain a major limitation in the future.In addition to predicting the trajectory, these models can estimate the amount of evaporation, the possibility of emulsification, the amount of dissolution and the trajectory of the dissolved component, the amount and trajectory of the portion that is naturally dispersed, and the amount of oil deposited and remaining on shorelines.Oil Spill particle modeling is now a very important part of both contingency planning and actual spill response. Spill models operate in a variety of modes. The most typical is the trajectory mode that predicts the trajectory and weathering of the oil. The stochastic mode uses available data to predict a variety of scenarios for the oil spill, which includes the direction, fate, and property changes in the oil slick. In another mode, often called the receptor mode, a site on the shore or water is chosen and the trajectory from the source of the oil is calculated. Increasingly, statistically generated estimates are added to oil spill models to compensate for the lack of accurate knowledge of winds and currents.The importance of a computer program cannot be over emphasized, especially for cases/situations that require predictions/forecasting. In its place is the sensitivity map which was drawn from information extracted from both satellite and maps in Ghana. The essence of it is for the location of resources that could be affected by an oil spill. Sensitivity map, though has several advantages, the prediction of how susceptible a resource in a locality and the fate of oil spill particle in the event of any spill accident are beyond it's limit, as detailed in Figure 2.

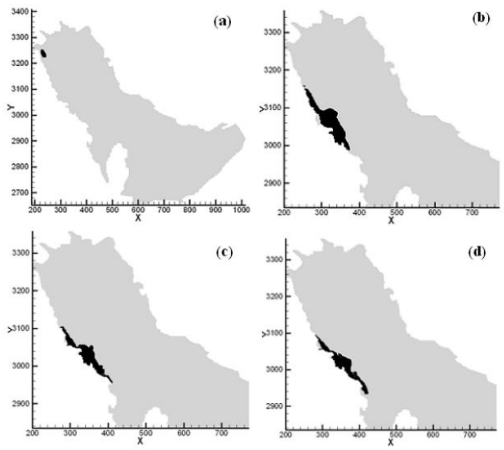

Figure 2: *The predicted positions of the slick due to Al-Ahmadi spill in 1991 (a) initial location (b) 18 days (c) 28 days (d) 35 days after spill [18]*

Numerical Investigation of the behaviour/fate of oil spill particles

Oil Spills can occur at any point in the EEZ of Ghana; a blow out from the sea bed and/or an accident in the column or surface of the sea waters. All these points form the principal locations where oil can get into the water as pollutants from either natural or human activities. The need for contingency plans for Ghana coastal water is obvious as the country has sensitive resources at the coastal belt and any reliable model will allow both researchers and responders alike to carry out various spill scenarios without polluting the shore. Numerical modeling/simulation of possible spill scenarios to investigate the fate, transport and impact of oil through waterways, wetlands, and possible diversions is an essential predictive and decision-making tool. The aftermath of the world major spill accidents, such as Exxon Valdez and the BP oil spill in the Gulf of Mexico have heighten the need for the development of efficient oil spill response planning strategies [19], to reduce the environmental impact [13].

Conclusion

The argument in the introduction has shown the need and importance for the inclusion of water oil modeling software, (WOMS) in environmental sustainability and management aside contingency plans documents. Ghana as an emerging oil country with sensitive resources at its coast does not have enough software tools in-house to map, simulate or predict the movement of oil/fuel over time in the case of any spill. This when attended to will further strengthen and improve spill response and actions, while reducing environmental and social impact. It will also create an environment for the contingency plans to be tested, validated and upgraded. Such exercises not only maintain and increase the skills of the response personnel, but also

lead to improvements and fine tuning of the plan as weaknesses and gaps are identified.

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